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A Synchronous Tool for Innovation and Improvement of University Communication, Counseling and Tutoring: The WhatsApp Experience

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ABSTRACT
M-learning stands as a different way of learning and the use of WhatsApp appears to be an innovative and effective resource. The objective of this research is to evaluate the effects of the use of this communication tool in the academic monitoring, counseling and tutoring of university students in the Faculty of Education at the University of La Laguna. A control group (N=120) and an experimental group (N=120) of first-year students were established (undergraduate students in Childhood Education, Primary Education and Pedagogy) with the aim of knowing the effect of the use of WhatsApp. An ad hoc questionnaire was used to evaluate the development of both those competences related to academic work and performance and those transversal competences through the use of an m-learning tool based on peer tutoring. The results obtained have revealed important improvements as regards those competences related to time efficiency, planning and organization, and those related to active learning, decision making and motivation.

Keywords: university counselling, transversal competences, m-learning, WhatsApp

INTRODUCTION

There are many researches and contributions performed in the field of Educational Guidance and Counselling which emphasize the value of academic tutoring and counselling in Higher Education. The Organic Law on Universities (4/2007, April 7; article 46), makes explicit reference to the right of students to receive academic attention and orientation from teachers through a tutoring and counselling system adapted to the new requirements. The new methodological approaches, which have been used to support the new teaching methodologies, give a predominant role to the processes of university counselling and tutoring. The teacher-student dynamics becomes a unique opportunity both to perform an effective monitoring of the students' work and to promote their development (Costa, Tomás, & Sellés, 2017).

The offer of an innovative university tutoring can be regarded as a useful tool not only for a guided development of students' learning, but also for their monitoring and coordination.

According to the report on the Bologna Process in 2012, there exist many factors which are regarded as the most frequent reasons for dropping out or making a proper monitoring of those subjects the students are studying (Curaj, Scott, Vlasceanu, & Wilson, 2012; Lirola, & Fernández, 2009). Among these factors, the following ones should be highlighted: wrong choice of subjects, little or no adequate training or lack of involvement and commitment of students. Nevertheless, this report emphasizes the fact that several countries provide a series of services and tools to their university students. These services and tools have helped develop the systems of academic counselling, tutoring and psychological assistance for students, promoting, in this sense, the processes of academic adaptation of such students.

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Contribution of this paper to the literature

- The results of this research will open up new paths in the processes of university tutoring.
- The evidences found point to the need to improve the processes of counselling, tutoring and monitoring of students. In this sense, the m-learning tools are becoming essential tools to compensate the effects and gaps derived from face-to-face academic tutoring performed in a traditional way at the university.
- This experience is a first approach to future research lines in the field of academic tutoring and counseling as regards university students.

Moreover, these reports state that the use of these student support services is essential to improve the processes of learning development and performance in the tasks and autonomous work of the student (Papadakis & Kalogiannakis, 2017)

Therefore, we consider it essential to know the effect of the use of this synchronous communication tool (WhatsApp) in the processes of academic monitoring, counselling and tutoring of university students. The widespread use of WhatsApp, as a communication tool (more than 70% of Spanish people's mobile phones)[1], justifies its choice compared to other lesser-known tools such as Telegram.

LITERATURE REVIEW

In recent years, and more concretely after the implementation of the European Higher Education Area (EHEA), academic tutoring has taken an important role related to the academic promotion and success of university students, to such an extent that tutoring is presently considered as an educational quality indicator due to its relation with the improvement of results and students' satisfaction.

A fact that has been highlighted is absenteeism. It is a predictor of dropout among students. Some researches, such as that conducted by Fuente, Carpeño, Castejón, Martínez, and Lorente (2017), focus on the relation among the students' grades and absenteeism and the processes of counselling and tutoring in the university. According to these authors, students' tutoring and counselling in the university are essential to continue attending university and to get academic achievements. Studies such as that of Rodríguez, Hernández, Alonso, and Díez (2003) and Rodríguez (2013), propose different improvements as regard the processes of tutoring. They particularly emphasize the improvements related to teaching innovation and training as regards alternative spaces and tools for all students as Papadakis, Kalogiannakis and Zaranis (2017), and Papadakis, Kalogiannakis, and Zaranis (2018). However we think it is very important for the tutoring and counselling process in university students. They also propose the need to use strategies to allow greater flexibility in the present tutoring framework to introduce new guidelines and scenarios for student-teacher interaction and communication. According to this proposal, there must be a change in the teacher's role with the aim of promoting new scenarios in the students' counselling and tutoring (Romero-Cerezo, Zurita-Ortega, and Zurita-Molina, (2010). This model becomes possible with the use of alternative tools and procedures which promote active and permanent learnings based on continuous counselling.

In this sense, university tutoring has to be adopted as a process of assistance, guidance and counselling to students. This process must be based on the personalisation of learnings and on the development of personal, academic and professional competences developed throughout their studies from a dynamic perspective and taking into account their personal and professional project (Lobato & Echeverría, 2004).

As it has been observed, university counselling and tutoring are crucial in higher education (Lobato & Guerra, 2014; Neville, 2007). Both the technological development and globalization of education have promoted the development of technological tools and applications which have generated new concerns as regards the approaches, models and methods of the traditional academic tutoring. In this sense, authors such as Savickas et al. (2009, p.3) have suggested the reformulation of the academic tutoring and counselling approach, proposing the model "Life designing", based on the "urgent activation of development interventions of the individual, of the incorporation of counselling in their process of reflection and resolution of problems occurring in the personal, professional and occupational evolution". This modern conception emphasizes two basic elements: the individual's commitment in the creation of his/her own life project through a regular and systematic reflection (Di Fabio & Bernaud, 2010) and the necessary counselling on the part of professionals in different modalities and contexts (Paul, 2009). This approach makes us reflect upon the use of alternative tools to face-to-face academic tutoring, which promote the continuous monitoring and contact with students, what we call "full tutoring".

Recent studies such as those carried out by García (2014), Sanz (2014), Albaladejo et al. (2015), Gómez et al. (2015), Garzozi (2015), Johnston et al. (2015), Farmer, Liu, and Dotson (2016), Gende (2016), Jaén and Ramalho (2016), Rodríguez-Martínez, Valerio-Ureña, Cárdenas-Anaya, and Herrera-Murillo, (2016), de Mera and Cayuso

[1] El Mundo: http://www.elmundo.es/economia/2015/02/25/54ece95cca47414b488b456f.html

(2017), Podpliota, (2017), Suárez (2017), Wasserman and Zwebner (2017), Castro-León, del Castillo-Olivares, Pérez-Jorge, and Leiva-Olivenza (2018), Hrastinski, Cleveland-Innes, and Stenbom (2018), Samaie, Mansouri, and Qaracholloo (2018) show the positive effects of the use of WhatsApp as a synchronous communication tool within the framework of higher education, we are convinced that the use of this tool promotes the model which we have called "full tutoring" . The objective of this research is to evaluate the effects of the use of this communication tool in the academic monitoring, counselling and tutoring of university students in the Faculty of Education at the University of La Laguna. We consider that the results of this study will open up new paths in the processes of university tutoring.

University entrance and admission imply for new students a novel situation. In just over a month, students pass from the organizational working model of post-compulsory secondary education (High School) to a university working model. The transition from High School to University needs an adaptation process to university education. It is a critical stage which needs priority attention to avoid failure and drop out situations. This change produces in the student fear, anxiety, uncertainty, confusion, disorientation difficulties (academic, curriculum, interpersonal, administrative, informative difficulties among others). The lack of resources and strategies to make academic decisions which promote in students a greater autonomy and independence, requires processes and strategies which let them give meaning to their actions to ensure the improvement of the effectiveness in decision making processes. In many cases, these students suffer from a physical and affective uprooting and have to leave their homes and live in places which are close to the university settings, leaving their families and friends behind.

These aspects are significant conditioning factors to achieve students' adaptation to University and may negatively influence not only their motivation and level of satisfaction but also their learning and academic performance.

OBJECTIVES OF THE STUDY

To know to what extent the use of WhatsApp promotes:

1. Participation and collaboration of students in specific subjects or in situations related to academic orientation processes.
2. The updated use of academic information.
3. The autonomous work of students, solving in real time academic doubts to promote the continuation of students' work.
4. The recollection of relevant situations which are related to academic training and tutoring and counselling orientation.
5. Participation in spaces for collaboration among students to clarify, update or share information among all members of the learning community.
6. The use of this tool for tutoring and counselling as an alternative to face to face tutoring.
7. The processes of academic counselling and tutoring, both from the students' and teachers' points of view.

METHODOLOGY

Some basic principles related to guiding intervention are found in the basis of this proposal in educational innovation. Such principles are based on prevention, through the student's continuous clarification and counselling (active learning), as a teaching-learning strategy with a design and implementation focused on the promotion of continuous participation and analysis through the permanent communication and interaction process which this tool offers: motivation. Individual and group difficulties in the training process will be able to be detected, allowing us to reinforce and motivate the students, leading to the improvement of their expectations and chance of success through the use of an informal language which lets improve the participants' motivational climate.

A double support and counselling system will be developed. On the one hand, peer tutoring: the students from the different groups clarify and discuss specific problematic situations related to academic issues or tutoring. On the other hand, teachers' educational support and counselling will be the responsible for promoting the active and continuous use of this tool, asking questions, making comments, giving data or interesting links, etc.

The sample of participants in this research was made up of 120 students who were incorporated to the WhatsApp groups which were created for this study. See distribution in **Table 1**.

Table 1. Profiles of respondents

Subject	Degree	Age	Gender	Participants
Strategies for specific attention to student diversity	Master in Educational Psychology Intervention in contexts of formal and informal education.	Average age: 24,3 years old	Male (M): 4 Female (F): 12	Control: M=2 F=6 Experimental: M=2 F=6
Information and Communication Technologies	Degree in Early Childhood Education	Average age: 18,9 years old	Male: 6 Female: 40	M=3 F=20 Experimental: M=3 F=20
Inclusive activities for students: present educational challenges	Degree in Pedagogy	Average age: 20,3 years old	Male: 8 Female: 50	M=4 F=25 Experimental: M=4 F=25

Table 2. Related to the effects on the improvement of university students' competences

Competences related to academic work and performance	Transversal competences or skills
1.-Planning, organization and time management 2.-Active learning (attendance and participation in the learning community, decision-making, the use of WhatsApp as a tool for academic tutoring and counselling)	1. TEAMWORK. Capacity to actively participate to achieve a common objective subordinating individual interests to the objectives of the team. 2. ADAPTABILITY TO CHANGE. Capacity to adapt to changes, modifying, if it is necessary, the students' behaviour to achieve certain objectives, new information or adjust to changes in the environment, changes in the external environment or changes related to the requirements related to their academic work. 3. CONTINUOUS LEARNING. It is the capacity to find and share useful information to solve certain situations. 4.-COMMITMENT AND UNDERSTANDING OF THE ORGANIZATION. Capacity to consider as his or her own the objectives of the organization. 5. MANAGEMENT CAPACITY. Capacity to promote awareness in his/her group of the need to specific changes in the way of acting. 6. ORGANIZATION AND PLANNING. Capacity to effectively determine the objectives and priorities of their tasks/ areas/ projects, providing action, deadlines and those resources required. 7. SUCCESS ORIENTATION/ RESULTS. Obtaining positive results.

The process and development of this study involved the following series of tasks:

1. A training seminar on strategies to promote learning through information and communication technologies (ICT), (forum dynamics, chats and synchronous communication spaces), paying special attention to effective communication processes and to the acquisition of necessary competences to apply the development of virtual communities as an innovative tool in the educational context.
2. Creation of learning communities to promote WhatsApp as a tool to improve academic monitoring, counselling and tutoring of each tutor who participated in this research.

Taking into account those data collected by teachers related to the students' participation, the following results were analyzed according to their effect on: *a) Competences related to academic work and performance b) Transversal competences* (**Table 2**). The effect of the use of WhatsApp on the improvement of such competences has let us evaluate the advantages of the use of this tool to improve learning, tutoring, monitoring and counselling processes of the students who participated in this research.

An ad hoc questionnaire was used to evaluate the development of both those competences related to academic work and performance and those transversal competences through the use of an m-learning tool based on peer tutoring (Herrera & Enrique, 2008). Although this is a test which has been concretely developed for this research, we applied the "Use and Satisfaction Questionnaire on University Tutoring (CUSTU)" created by Clares, Cusó, and Juárez (2016) made up by different areas which try to collect the students' opinions as regards the different aspects of university tutoring and the use of WhatsApp as a tool to develop both general and transversal competences.

A scale was designed taking into account a questionnaire with Likert-type questions with five levels of answers. Each answer was valued punctuating from 1 (the lowest level of agreement) to 5 (the highest level of agreement).

Table 3. Reliability analysis of the questionnaire: subscales, number of items and value of α Cronbach

Subscales	Nº items	α Cronbach
1. Teamwork.	6	0.801
2. Adaptability to change.	4	0.813
3. Continuous learning.	3	0.711
4. Commitment and understanding of the organization.	4	0.764
6. Management capacity.	4	0.798
7. Organization and planning.	5	0.761
8. Success orientation/ results	5	0.807
Total	**31**	**0.864**

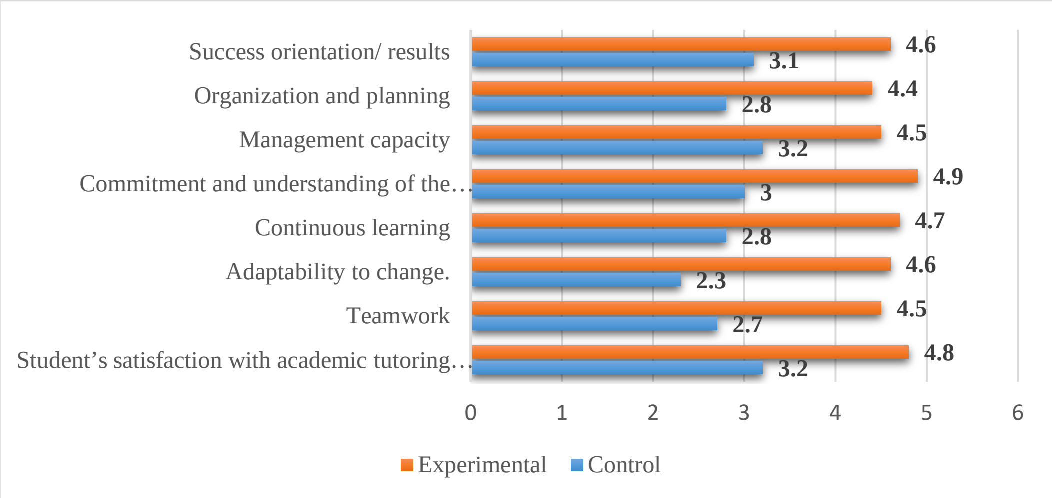

Figure 1. Average scores for each factor (Control/Experimental)

Taking into account the scores given by the participants to each of the items, an analysis of the main components was performed through the VARIMAX rotation procedure. The index KMO of sampling adequateness obtained an acceptable value of 0.864, and enabled us to proceed with factorization (Bartlett test of sphericity; $\chi 2$= 30.1, 1253 gl, p< 0.000). We decided to opt for 7 factors or components which explained a 58.7% of the variance.

FINDINGS OF THE STUDY

In order to analyze the results obtained, we compare the average scores (T Test) in the control and experimental group according to dimensional contrast. Furthermore, the results obtained were compared taking into account the different degrees (one-way Anova). **Figure 1** shows the average scores obtained in each group and in each of the dimensions analyzed.

Our results revealed differences as regards each of the factors included in the analysis.

General satisfaction with academic tutoring and counselling; there were differences between the control and the experimental group. Students who did not participate in the experience of academic tutoring and counselling through m-learning (WhatsApp) ($\bar{\chi}_1$=3.2) showed a worse perception and satisfaction of this factor than those students who were supervised and tutored through WhatsApp ($\bar{\chi}_2$= 4.8). (F*(1,2)*= 0.507; p=0.002).

As regards the remaining dimensions, the results were the following ones: *teamwork* [($\bar{\chi}_1$= 2.7; $\bar{\chi}_2$= 4.5; F*(1,2)*= 0.187; p=0.003)]; *adaptability to change* [($\bar{\chi}_1$= 2.3; $\bar{\chi}_2$= 4.6; F*(1,2)*= 0.237; p=0.001)]; *continuous learning* [($\bar{\chi}_1$= 2.8; $\bar{\chi}_2$= 4.7; F*(1,2)*= 0.569; p=0.005)]; *commitment and understanding of the organization* [($\bar{\chi}_1$= 3.0; $\bar{\chi}_2$= 4.9; F*(1,2)*= 0.402; p=0.002)]; *management capacity* [($\bar{\chi}_1$= 3.2; $\bar{\chi}_2$= 4.5; F*(1,2)*= 2.673; p=0.000)]; *organization and planning* [($\bar{\chi}_1$= 2.8; $\bar{\chi}_2$= 4.4; F*(1,2)*= 2.319; p=0.001)]; *success orientation/ results* [($\bar{\chi}_1$= 3.1; $\bar{\chi}_2$= 4.6; F*(1,2)*= 7.249; p=0.003)]. Significant differences were observed for each of the dimensions analyzed in this study. This fact revealed an improvement of the results in the experimental group compared to the control group which did not work with the m-learning tool based on peer tutoring.

CONCLUSION

The use of WhatsApp (m-learning) as a tool to develop the processes of university counselling and tutoring has proven to be effective. In general, students have had easy access to any kind of information, anywhere at any time.

This has let them participate actively in the planning and development of tasks, being informed of those changes and modifications performed during the academic course and having updated and useful information. Moreover, they have been able to be actively involved in learning tasks and improve their level of motivation and involvement in the academic work. As opposed to the control group, the students have expressed their satisfaction and the advantages of this tutoring method as compared to other traditional methods.

The flexibility that the use of WhatsApp offers and its permanent availability make it a useful resource for academic tutoring and learning achievement. The introduction of a system of academic tutoring and counselling, such as the one we have put into practice in this research experience, opens the way for the development of other possibilities which let complement the students' academic training. In this sense, an autonomous learning, in which it is not necessary to attend face-to-face counselling sessions to acquire and develop competences and knowledge, is developed.

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https://drive.google.com/file/d/0B_NWxPjo5wSpYTcxVUUxM2RUbG8/view

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The Developmental Changes of Number Processing and Calculation Abilities in Chinese Primary School Students

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ABSTRACT

Based on the 'triple-code' theory, the present study provided a comprehensive examination of the development of number processing and calculation abilities of Chinese primary school students. 310 children from grade 1 to grade 4 were assessed using the battery of number processing and calculation tests (NUCALC-R (Protocol)), covering tests of the Verbal, Visual Arabic and Analogue Magnitude Modules of the numerical abilities. The results showed that the three modules had different developmental trajectories from grade 1 to grade 4: the Verbal Module and Analog Module reached a plateau in grade 3, but the Visual Arabic Module improved gradually across the four grades. In addition, the subtests within each module also showed different developmental trajectories, demonstrating a rich profile of how the specific ways of representing and manipulating the numerals in a given module develop in the early school years.

Keywords: number processing and calculation, the triple-code model, development, NUCALC-R

INTRODUCTION

The importance of number processing and calculation abilities for an individual's success in the modern society makes it critical to understand how these abilities develop. The well-received triple-code model provides a comprehensive conceptual framework to examine the development of these numerical abilities, as it captures both the heterogeneity and the common structures among them. According to this model, the numerical abilities could be classified into three modules (i.e., the Analog Magnitude Module, the Verbal Module and the Visual Arabic Module), with each manipulating different forms of internal representations of numbers and being used for different numerical processing tasks (Dehaene, 1992). However, so far, little has been known about how these separate modules develop, as the existing studies have mainly focused on the development of one or just a few isolated abilities within a given module. The present investigation aims to delineate the developmental trajectories of these three modules of numerical cognition from grade 1 to grade 4 in the primary school. To serve this purpose, Neuropsychological Test Battery for Number Processing and Calculation in Children (NUCALC) was used (von Aster, 2000), which include different subtests tapping each of the three modules of the triple code model. Compared to the previous studies, this presents a more comprehensive picture of how the number processing and calculation abilities develop in the early years of schooling, both at the macro-level of modules and the micro-level of each single ability.

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Contribution of this paper to the literature

- In a single study we provide a comprehensive test of how three modules of number processing and calculation abilities develop in early years of schooling.
- This study also reveals how the constituent abilities within each module develop differently in a single study.
- It delineates a rich profile of the development of numerical processing abilities of Chinese primary school students.

The Triple-Code Theory

The overwhelming evidence of the heterogeneity of developmental dyscalculia indicates that the development of mathematical abilities is not a unidimensional process (e.g., Dehaene & Cohen, 1997; Peake, Jimenez, & Rodrigues, 2017). Therefore, we need a comprehensive conceptual framework to describe and explain the development of such multidimensional abilities.

The first such attempt was made by McCloskey and his colleagues (McCloskey, 1992; McCloskey, Caramazza, & Basili, 1985). According to McClockey's model, numerical processing involved three separate systems that each corresponded to a specific cognitive function: the number comprehension system, calculation system, and number production system. According to this model, the comprehension system transforms numerical input into an abstract internal representation, i.e., the semantic code, which serves the input for the calculation system. In addition, the semantic codes generated by these two systems also provide input to the number production system that transforms the abstract codes into verbal (e.g., "seven") or Arabic number forms (e.g., "7"). Calculation involves operational words (more, less, times, divide) and operation symbols (+, –, × or ÷), retrieval of them and arithmetic facts, and calculation procedures. Although the distinctions between these systems have been clearly supported by the neuropsychological evidences (e.g., McCloskey, 1992; McCloskey et al., 1985), the notion of exclusively abstract number representations was not supported by further analysis on the errors made by the brain-damaged subjects (e.g., Campbell & Clark, 1988), and also was inconsistent with the meta-analyses on 19 fMRI studies on numerical cognition (Kaufmann, Wood, Rubinsten, & Henik, 2011). Format-specific representations were thus incorporated in several alternative models (Campbell & Clark, 1988; Dehaene, 1992; Dehaene, Piazza, Pinel, & Cohen, 2003; Kaufmann et al., 2011; Noel & Seron, 1993). However, the most influential one, the encoding-complex hypothesis goes to the other extreme by postulating a network of specific-format codes that were differentially recruited in different mathematical tasks for a given individual, depending upon an individual's idiosyncratic learning history, culture-specific strategies and other factors (Campbell & Clark, 1988; Campbell & Epp, 2004).

The 'triple-code' model proposed by Dehaene (1992) reconciled the two opposing perspectives on the number representations. This model proposes three distinct modules for number representation: the Analog Magnitude Module that is format-independent, and the Verbal Module and Visual Arabic Module that are format-dependent. The Analogical Magnitude Module represents numerical quantities analogically over a left-to-right oriented mental number line, and it is independent of language and available in preverbal infants and animals. According to this model, this module underlies automatic access to approximate quantities in the tasks of quantity comparison (e.g., "is five smaller than nine?") and approximation (e.g., estimate the number of apples in the box without counting). The Verbal Module represents numerical information in a verbal-presentation code (e.g., /thirteen/), which is created and manipulated by the language systems. This module is required for counting (e.g., count from 1 to 10), and tasks such as single-digit multiplication (e.g., "5×3=?") and addition (e.g., "5+3=?") that involves direct retrieval of arithmetic facts from the long-term memory (e.g., addition and multiplication tables). The Visual Arabic Module, where strings of Arabic digits are encoded as Arabic codes (e.g., "13"), subserves parity judgments (e.g., "is 5 an odd number?") and multi-digit operations (e.g., "56+120 =?"). It has been found that semantic knowledge of parity is accessed via a base-ten representation (i.e., the ten possible values of a number's rightmost digit) in Arabic form (Dehaene, Bossini, & Giraux, 1993). The multi-digit operations involve the sequential combination of elementary arithmetical operations and thus are more complex. It has been documented that the understanding of the base-ten place-value structure in Arabic form is also critical (e.g., Nuerk, Weger, & Willmes, 2001; for a review, see Klein, Bahnmueller et al., 2013). In addition, multi-digit calculations involve frequent translation between Arabic and verbal codes because direct retrieval of arithmetic facts is often needed, and also involve orienting of visual-spatial attention so as to mentally manipulate the spatial image of the operation in Arabic notation (Hubbard, Piazza, Pinel, & Dehaene, 2005).

The triple-code model has been well supported by abundant of neural evidence (for a meta-analysis, see Kaufmann et al., 2011; for a review, see Siemann & Petermann, 2017). The neuropsychological studies have revealed dissociations and double dissociations among these three systems. For example, patients with the left perisylvian damages were impaired in tasks requiring verbal representations of numbers, but could accomplish tasks involving quantity or Arabic representations (e.g., Dehaene & Cohen, 1997; Lemer, Dehaene, & Cohen, 2003). In contrast, the patients with parietal lesions were impaired in tasks involving quantity representations (e.g., Dehaene & Cohen, 1997; Delazer & Benke, 1997; Kaufmann et al., 2011). In addition, patients with pure alexic resulted from lesions in the inferior temporal gyrus failed to read aloud the visually presented digits and the operands, but could perform number comparison or old-even judgment, even with 2-digit numerals (Cohen & Dehaene, 2000).

In line with the above neuropsychological evidence, the neuroimaging studies have also found that the Analog Magnitude, Verbal, and Visual Arabic modules are subserved by the bilateral inferior parietal, left perisylvian (e.g., angular gyrus and inferior frontal gyrus) and ventral occipitotemporal areas respectively (for a meta-analysis, see Kaufmann et al., 2011; for reviews, see Abboud, Maidenbaum, Dehaene & Amedi, 2015; Siemann & Petermann, 2017). For example, it has been revealed that Arabic digits and verbal numerals elicited similar activations in the inferior parietal lobe, suggesting a format-independent magnitude representation in this region (Holloway & Anaari, 2008; Libertus, Woldorff, & Brannon, 2007), but the Arabic digits elicited more activation in the inferior temporal gyrus than the verbal numerals (e.g., Shum et al., 2013). Further, a visual number form area (VNFA) that showed selectivity to Arabic digits was identified in the middle of the inferior temporal gyrus, which was close to the visual word form area (VWFA), but was connected to the intraparietal cortex that represented the quantities instead of the language areas (Abboud et al., 2015). In addition, tasks of approximate calculation and exact calculation led to greater activation in the parietal lobes and the inferior frontal lobe respectively (e.g., Dehaene et al., 1999, 2003). Using the exploratory group independent component analysis (ICA), another study processed the fMRI data from participants performing complex mental addition and subtraction of fractions and revealed separate task-related components in bilateral inferior parietal, left perisylvian and ventral occipitotemporal areas, also lending support to the triple-code model (Schmithorst & Brown, 2004). Recently, the transcranial direct current stimulation (tDCS) was adopted and provided causal evidence for the links between these brain regions and these three codes (e.g., Artemenko, Moeller, Huber, & Klein, 2015; Klein, Mann et al., 2013).

In sum, the dissociations of the three modules proposed by the triple-code model have been extensively reported by the neuroimaging and neuropsychological studies, making this theory be recognized as the most popular neuro-functional model for number processing and calculation (see Kaufmann et al., 2011). However, far more less has been known about how these separate modules develop, especially during the first few school years. In fact, in contrast to the above findings from the adult participants, studies on children failed to found dissociable neural circuits for the approximate and exact calculations (e.g., Kucian, von Aster, Loenneker, Dietrich, & Martin, 2008; Molko et al., 2003), which suggests that these modules might undergo developmental changes over time.

The Development of the Three Modules

The previous studies on the development of the mathematical abilities have mainly been focusing on the developmental changes of a single or a few abilities in a single module, and thus could not inform how the modularized systems develop. For example, the studies on the development of the number comparison and estimation abilities have shown that the analog representation was in shape even with the newborn babies (Izard, Sann, Spelke, & Streri, 2009; McCrink & Wynn, 2004; Xu & Spelke, 2000), and underwent a logarithmic-to-linear shift with age in representing numbers via a mental number line, indicating the refinement of education on this innate core system (Booth & Siegler, 2006, 2008; Pinel & Dehaene, 2013; Siegler & Booth, 2004; von Aster & Shalev, 2007). For another example, studies on how the mathematical abilities supported by the Verbal Module develop showed that counting was a preverbal ability and it matured before the school age (Wynn, 1992), and that calculation started with a strategy of finger counting at around four years old, moved up to adding without fingers with the minimum strategy at around 5 years old (Dehaene, 2011), and then to arithmetic facts retrieval, which became more automatized and in more complex forms during the preschool to the primary school years (Miller & Paredes, 1990). For the third example, the development of multi-digit manipulation supported by the Visual Arabic Module received more attention in the recent years. It has been found that early understanding of place-value structure at grade 1 could predict the arithmetic performance at grade 3 (Moeller, Pixner, Zuber, Kaufmann, & Nuerk, 2011). In another longitudinal study from grade 2 to grade 4, the hundred-distance effect and the unit-hundred compatibility effect showed an increasing trend with grade level, suggesting more and more parallel processing of different positions (Mann, Moeller, Pixner, Kaufmann, & Nuerk, 2012).

One might argue that these studies that focused on one or only a few abilities of numerical processing, when viewed collectively, could inform how the different modules and the constituent sub-abilities might differ in terms of the developmental trajectories. However, because these studies differed in numeral methodological aspects, it is simply impossible to make a fair comparison between them. As a result, these previous studies were not only unable to reveal the overall developmental patterns of the modules, but also were ineffective in revealing the variations of the sub-abilities within each module.

To serve the purpose of testing the three modules effectively in a single study, Neuropsychological Test Battery for Number Processing and Calculation in Children (NUCALC) was developed (von Aster, 2000). Functional analysis confirmed that sub-tests NUCALC could be organized into three clusters, fitting well with the three modules of Dehaene's triple code model (Santos et al., 2013; von Aster, 2000). There have been behavioral studies that used NUCALC to examine the age or grade effect on children across countries (Dellatolas, von Aster, Willadino-Braga, Meier, & Deloche, 2000; Koumoula et al., 2004; Santos et al., 2013). These studies revealed an age-related improvement in Score A, which consisted of six subtests that were associated with schooling achievement (dictation and reading of numbers, mental calculation addition part, problem solving, and oral and written comparison). However, by narrowing down the focus to these subtests, these studies did not inform how the three big modularized systems develop. In addition, by collapsing the subtest scores, these studies also did not reveal how the subtests that tapped different aspects within each module might differ in terms of the developmental patterns.

The Present Study

Therefore, based on the 'triple-code' theory, the present study aimed to adopt NUCALC-R (Protocol) to examine the developmental changes of three modules of numerical abilities in Chinese children from the grade 1 to grade 4. In addition to comparing the overall developmental trajectories of the three modules across the grades, the present study also delineated the developmental variations among the subtests within each module. This will provide not only a better view of the modularized organization of the number processing and calculation in Chinese children, but also the variations of different aspects of representing and manipulating numerals in a particular code. Findings from this study will potentially fertilize more effective teaching practices in classrooms, which in turn will also help inform and refine the current models of the numerical cognition.

Based on the previous studies, we hypothesize that in general, children from the higher grades will perform better than those from the lower grades for all three modules. However, the grade effect might be lower for the Analogue Magnitude Module than the Verbal and Visual Arabic modules, as the former has been in position in the early infancy and thought of as innate abilities. In addition, the subtests within each module will demonstrate different developmental trajectories, determined by the difficulties of the specific ways of representing and manipulating the numerals in that code.

METHOD

Participants

310 primary school students from grade 1 to grade 4 were recruited from three schools in Beijing. The numbers in each grade was 40 (23 boys), 60 (37 boys), 81 (51 boys) and 129 (86 boys). None of these students had any physical deficits (e.g., hearing impairment) or mental retardation. The schools were evaluated to be good, average and below-average respectively based on the education level of school faculty, school facilities and the performance level of students. One class was randomly selected in each grade from grade 1 to grade 4 in all the selected schools except that for Grade 4 two classes were selected in the first school.

Measurements

The measurements were the Neuropsychological Test Battery for number Processing and Calculation in Children-revised (Protocol) (NUCALC-R (Protocol)) (von Aster & Weinhold, 2002) that was translated and revised for use in China (Zhang & Dong, 2006). Our previous study administered the NUCALC-R (Protocol) on Chinese primary school students and the confirmatory factor analysis revealed an acceptable fit with the 'triple-code' model (Zhang & Dong, 2006). Specifically, the confirmatory factor analysis indicated that the Verbal Module includes dot enumeration (DE), verbal countdown (VC), mental calculation (MC), digit span (DS) and solving arithmetical problems (SAP); the Visual Arabic module includes transcription of dictated numbers (TDN), reading numbers (RN) and comparison of numbers as digit (transcribed) (CND); the Analog Magnitude Module comprises matching visual presentations of numerals to their corresponding positions on a vertical scale (MVPTCPVS), comparison of two numbers (verbally) (CTN), perceptual estimation of quantities (PEQ) and estimation of quantities in context (EQC). Below the subtests in each module are introduced.

The verbal module

Dot enumeration (DE). The child was asked to count aloud the dots displayed on two cards while pointing at each dot, and then write down the result.

Verbal countdown (VC). The child was asked to count backwards from 23 to 1. It requires producing the verbal sequence under the control of working memory and is a prerequisite for children to learn subtraction (Fuson, Richards, & Briards, 1982).

Mental calculation (MC). Addition (e.g., 5+8 = 13) and subtraction (e.g., 32-17=15) were tested. Multiplication in the original version was excluded for lack of discriminative power on Chinese children. Probably due to extensive drilling of multiplication rules, Chinese children who have learned multiplication at school solved all the multiplication items correctly, whereas those haven't learnt solved none.

Digit span (DS). It included two parts, digit span forwards and digit span backwards. It was to measure the short-term storage and manipulation capacity of numbers.

Solving arithmetic problems (SAP). The child was asked to solve arithmetical problems of increasing difficulty. For example, "Peter has 12 marbles. He gives five to his friend Ann. How many marbles has he got left?"

The visual Arabic module

Reading numbers (RN). The child was asked to read aloud numbers written in Arabic numerals (e.g., 72). It required the child to transcode the numbers from the Arabic to the verbal form.

Transcription of dictated numbers (TDN). The child was asked to write down eight numbers (e.g., 14) in Arabic numerals that were presented orally by the experimenter.

Comparison of two numbers as digits (transcribed) (CTND). The numbers were presented in pair as Arabic numerals (e.g., 79 vs. 81). The child was asked to point out the larger one.

The analog magnitude module

Matching visual presentations of numerals to their corresponding positions on a vertical scale (MVPTCPVS). The child was asked to point to the small horizontal line that corresponds to a number presented as an Arabic numeral. The aim of this subtest was to examine the comprehension of the number as a quantity.

Comparison of two numbers (verbally) (CTNV). Pairs of numbers were presented orally. The child had to say which of the two numbers was larger.

Perceptual estimation of quantities (PEQ). The child was asked to orally estimate the quantity of objects in a picture that was presented for 5s only. This subtest examined how numbers were associated with quantities in the child's internal representations.

Estimation of quantities in context (EQC). The child was asked to estimate quantities in specific sentential contexts (e.g., Two clouds in the sky) on a scale of three (a little, average, or a lot). This subtest examined the understanding of the semantic values of numbers in the specific contexts.

Procedure

A psychologist and trained schoolteachers administered the test battery. All of the 12 subtests were individually administered in quiet rooms. It took about 30 minutes for each child.

Statistical Analysis

The data were analyzed with SPSS 19. One-Way ANOVA was used to test the grade effects in the modules and subtests scores. Further, the post-hoc tests were used to reveal the grade differences in more details.

RESULTS

Each item in all the subtests scored between 0-2, and thus the average score for each subtest and each module was in the same range. All the following analysis was based on the averaged scores.

The Development of the Verbal Module

The Verbal Module includes the subtests of dot enumeration (DE), verbal countdown (VC), mental calculation (MC), digit span (DS) and solving arithmetical problems (SAP). The means and standard derivations of each of these subtests and the grand mean of the module for each grade are reported in **Table 1**. The growth trajectories of the module mean scores were also displayed in **Figure 1**.

Table 1. The Descriptive Analysis of the Verbal Module Subtests

Subtests	Grade 1 M (SD)	Grade 2 M (SD)	Grade 3 M (SD)	Grade 4 M (SD)
DE	1.54(.43)	1.73(.40)	1.79(.36)	1.81(.34)
VC	1.09(.78)	1.56(.55)	1.65(.53)	1.76(.42)
MC	0.87(.38)	1.44(.35)	1.62(.26)	1.67(.25)
DS	1.38(.21)	1.47(.23)	1.59(.20)	1.57(.21)
SAP	0.83(.57)	1.20(.49)	1.51(.44)	1.60(.35)
Verbal Total	1.14(.32)	1.48(.23)	1.63(.21)	1.68(.18)

Note. DE= dot enumeration; VC= verbal countdown; MC= mental calculation; DS=digit span; SAP=solving arithmetical problems.

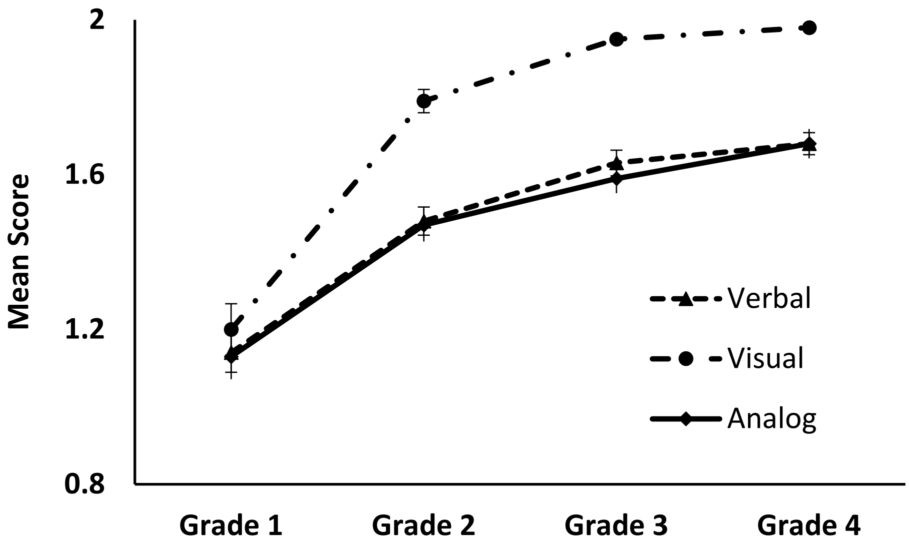

Figure 1. The growth curves of the three modules from grade 1 to grade 4

Table 2. One-Way ANOVA on the Grade Effect and Post-hoc Analysis for the Module and Subtest Scores of the Verbal Module

Subtests	*df*	Grade	Grade Comparisons
DE	3, 306	6.00***	Grade4, Grade3 & Grade2 > Grade1
VC	3, 306	16.55***	Grade4, Grade3 & Grade2 > Grade1
MC	3, 306	81.29***	Grade4 & Grade3 > Grade2 > Grade1
DS	3, 306	12.55***	Grade4 & Grade3 > Grade2 > Grade1
SAP	3, 306	37.13***	Grade4 & Grade3 > Grade2 > Grade1
Verbal Total	3, 306	67.22***	Grade4 & Grade3 > Grade2 > Grade1

Note. DE= dot enumeration; VC= verbal countdown; MC= mental calculation; DS=digit span; SAP=solving arithmetical problems. *p < .05. ** p < .01. *** p < .001.

As the students from the four grades were independent groups, One-Way ANOVA was used to test the grade effects in the average module score and the subtest scores. The assumptions of One-Way ANOVA were also met (here and later for the rest modules). As **Table 2** displays, this analysis revealed a significant grade effect in the average module score of the Verbal Module, F (3,306) =67.22, p < .001. The grade effect for each subtest of this module was also significant (all ps< .001). The post-hoc tests further showed that grade 1 had significantly lower scores on all the subtests and module scores than the other grades (all ps < .001); grade 2 had significantly lower scores on all the subtest and module scores than grade 3 and grade 4 (all ps < .001), except that the scores of dot enumeration and verbal countdown were not significantly different from those of grade 3 (all ps>.05); grade 3 and grade 4 were equivalent across all the subtests and the module score (all ps>.05).

The Development of the Visual Arabic module

The Visual Arabic module includes the subtests of Transcription of dictated numbers (TDN), Reading numbers (RN), and Comparison of two numbers as digits (transcribed) (CTND). The means and standard deviations of the module score and the subtest scores for each grade were shown in **Table 3** and **Figure 1**.

Table 3. The Descriptive Analysis of the Visual Arabic Module Subtests

Subtests	Grade 1 M (SD)	Grade 2 M (SD)	Grade 3 M (SD)	Grade 4 M (SD)
TDN	0.9(.64)	1.71(.37)	1.96(.1)	1.97(.08)
RN	1.11(.58)	1.76(.25)	1.96(.09)	1.99(.05)
CTND	1.59(.35)	1.9 (.17)	1.92(.14)	1.98(.08)
Visual Total	1.2(.42)	1.79(.19)	1.95(.06)	1.98(.04)

Note. TDN=transcription of dictated numbers; RN=reading numbers; CTND= comparison of two numbers as digits (transcribed).

Table 4. One-Way ANOVA on the Grade Effect and Post-hoc Analysis for the Module and Subtest Scores of the Visual Arabic module

Subtests	*df*	Grade	Grade Comparisons
TDN	3, 306	155.41***	Grade4 & Grade3 >Grade2 > Grade1
RN	3, 306	147.55***	Grade4 & Grade3 > Grade2 > Grade1
CTND	3, 306	53.73***	Grade4 > Grade3 & Grade2 > Grade1
Visual Total	3, 306	214.48***	Grade4 > Grade3 > Grade2 > Grade1

Note. TDN=transcription of dictated numbers; RN=reading numbers; CTND= comparison of two numbers as digits (transcribed). *$p < .05$. ** $p < .01$. *** $p < .001$

Table 5. The Descriptive Analysis of the Analogue Magnitude Module Subtests

Subtests	Grade 1 M (SD)	Grade 2 M (SD)	Grade 3 M (SD)	Grade 4 M (SD)
MVPNTCPVS	1.16(.68)	1.54(.46)	1.65(.42)	1.71(.41)
CTNV	1.22(.59)	1.70(.25)	1.85(.22)	1.84(.23)
PEQ	1.22(.62)	1.50(.57)	1.56(.54)	1.72(.45)
EQC	0.94(.4)	1.13(.43)	1.28(.45)	1.44(.41)
Analogue Total	1.13(.37)	1.47(.27)	1.59(.24)	1.68(.24)

Note. MVPNTCPVS=matching visual presentations of numerals to their corresponding positions on a vertical scale; CTN=comparison of two numbers (verbally); PEQ= perceptual estimation of quantities; EQC=estimation of quantities in context

As **Table 4** displays, one-way ANOVA revealed a significant grade effect in the average module score of the Visual Arabic module, F (3,306) =214.48, $p < .001$. The grade effect for each subtest of this module was also significant (all ps < .001). The post-hoc test showed that the module score increased significantly as the grade increased (all ps <.05). The same was true for the comparison of two numbers as digits (transcribed) (CTND), but for transcription of dictated numbers and reading numbers (TDN), there was a significant increase except from grade 3 to grade 4.

The Development of the Analog Magnitude Module

The Analog Magnitude Module includes the subtests of matching visual presentations of numerals to their corresponding positions on a vertical scale (MVPNTCPVS), comparison of two numbers verbally (CTN), perceptual estimation of quantities and estimation of quantities in context (EQC). The means and standard deviations of the module score and the subtest scores for each grade were shown in **Table 5** and **Figure 1**.

As **Table 6** shows, One-Way ANOVA revealed a significant grade effect for the overall score of the Analog Magnitude Module, F (3,306) =44.5, $p < .001$, and for all of its subtests (all ps<.001). The post-hoc tests showed that the module score reached asymptote at grade 3. The same was true for Comparison of two numbers as digits (transcribed). The subtest of perceptual estimation of quantities seems to be the easiest, as it stopped growing at grade 2, and Estimation of quantities in contest seems to be the hardest, as it had a significant increase from every grade to its next ($p < .001$). The subtest of matching visual presentations of numerals to their corresponding positions on a vertical scale increased from grade 1 to grade 2, ceased to grow from grade 2 to grade 3, but continued to increase from grade 3 to grade 4.

Table 6. One-Way ANOVA on the Grade Effect and Post-hoc Analysis for the Module and Subtest Scores of the Analogue Magnitude Module

Subtests	*df*	Grade	Grade Comparisons
MVPNTCPVS	3, 306	14.87***	Grade4, Grade3 & Grade2 > Grade1
CTNV	3, 306	47.75***	Grade4 & Grade3 > Grade2 > Grade1
PEQ	3, 306	9.86***	Grade4 & Grade3 & Grade2 > Grade1
EQC	3, 306	17.09***	Grade4 > Grade3 > Grade2 > Grade1
Analogue Total	3, 306	44.5***	Grade4 & Grade3 > Grade2 > Grade1

Note. MVPNTCPVS=matching visual presentations of numerals to their corresponding positions on a vertical scale; CTN=comparison of two numbers (verbally); PEQ= perceptual estimation of quantities; EQC=estimation of quantities in context. *p < .05. ** p < .01. *** p < .001.

DISCUSSION

The present study for the first time examined the developmental changes for the Visual, Verbal and Analog Magnitude Module of numerical processing and calculation from grade 1 to grade 4 in the primary school. The results showed that the three modules had different patterns of changes across the four years: whereas the performance of the Visual Arabic module increased from grade 1 to grade 4, both the verbal and Analog Magnitude Module reached a plateau at grade 3. In addition, the subtests within each module also showed different developmental trajectories across the four grades, revealing a rich profile of how the specific ways of representing and manipulating the numerals in a given code develop in the early school years.

The Verbal Module score was the lowest in grade 1, improved significantly from grade 1 to grade 2, and then reached a plateau at grade 3. The growth from grade 1 to grade 2 might be driven by multiple factors, such as more arithmetic facts being acquired during the first year of formal education, accumulation of experiences, and the development of processing speed (e.g., Fry & Hale, 1996). The plateau observed at grade 3 was similar to that observed in Greek children with the same protocol of NUCALC (Koumoula et al., 2004). A possible explanation for this phenomenon was that the tests might be too easy for the higher graders, as they were designated to diagnose children with the developmental dyscalculia (von Aster, 2000). Interestingly, here we found that the plateau occurred one year earlier than that in Greek children. This fits with the extensive cross-cultural evidence that Chinese children enjoy an advantage in mathematics over the Western peers, presumably because the verbal forms of digits in Chinese are shorter than those in the alphabetical languages and presents a less load for the verbal short-term memory (Dehaene, 2011). As for the individual subtests of the Verbal Module, all improved significantly from grade 1 to grade 2, but their developmental trajectories bifurcated thereafter. Dot enumeration and verbal countdown did not improve further after grade 2, which was consistent with previous evidence that counting was a precocious competence and served a foundation for the development of exact calculation (Wynn, 1992). Mental calculation, solving arithmetical problems and digit span showed steady improvement from grade 1 to grade 3, and emergence of stagnation in grade 3 and grade 4.

The Visual Arabic Module presented a gradual and continuous improvement from grade to grade. Although the amount of growth decreased across the grades and was in fact was small from grade 3 to grade 4, all the changes were statistically significant. There might be two main drives underneath this gradual improvement of this module across grades. The first drive might be children’s continuous acquisition of the Arabic notation system (e.g., the base-ten place-value structure) and written calculation procedures with increased difficulty in the school environment (Knops, Thirion, Hubbard, Michel, & Dehaene, 2009). The second drive could be the increasingly developed visual and spatial attention (e.g., Shimi, Nobre, & Astle, 2014). It has been revealed that mathematical processing, especially multi-digit manipulation requires the orientation of the visual-spatial attention (Hubbard et al., 2005; Maruyama et al., 2012) and that for children with Attention-Deficit Hyperactivity Disorder (ADHD), decrements in sustained attention could predict mathematical performance (Fosco & Hawk, 2017). Future studies should further explore the causal role of visual-spatial attention in the development of the Visual Arabic Module by using a longitudinal design or a training paradigm.

The Analog Magnitude Module overall showed a similar developmental trajectory with that of the Verbal Module, presenting a continuous growth till a plateau was reached at grade 3. This pattern suggests that the Analog module might have reached a stable state at grade 3, corroborating with one recent imaging finding that the third- and sixth-graders had no significant differences in their brain activations when performing approximate calculation and magnitude comparison (Kucian, von Aster, Loenneker, Dietrich, & Martin, 2008). The individual subtests of the Analog Magnitude Module all improved significantly from grade 1 to grade 2, but their developmental trajectories thereafter were different from test to test. Perceptual estimation of quantities and matching visual presentations of numerals to their corresponding positions on a vertical scale stopped to grow at grade 2. This suggests that although the ability of perceiving quantity has been in shape before schooling or even at birth as the previous studies suggested (Cantlon, Brannon, Carter, & Marrero, 2006; Wynn, 1992; Xu & Spelke, 2000), it could be refined by education. The comparison of two digits (verbally) did not stop until grade 3, whereas estimation of quantities in context showed a continuous growth from grade 1 to grade 4. Such developmental changes can be interpreted as a refinement of the quantitative representation after exposures to numerical symbols, presumably in the left IPS of the brain (Pinel & Dehaene, 2013). This paralleled with the view of the four-step-developmental model of numerical cognition, which suggested the elaboration of the Analog Magnitude Module after symbolization of numbers during the school age (von Aster & Shalev, 2007).

LIMITATIONS

The present study had at least two limitations. First, it used a cross-sectional method to examine the developmental changes and thus the cohort effect might be an issue. Second, although our sample included the at-risk students, due to the small sample size we didn't examine whether they followed a different developmental pattern from the average ones for these three modules and the subtests. To overcome these limitations, we are currently planning a longitudinal study to trace the developmental patterns of number processing and calculation of both the typically developed and the at-risk students, and to delineate when, where and how much the latter deviates from the former.

CONCLUSION

In sum, the results of the present study indicated that the developmental changes of different modules of number processing and calculation were not of a uniform pattern. However, two commonalities did emerge. First, all three modules improved with grade, which was presumably driven jointly by maturation and experience (e.g., Izard, Sann, Spelke, & Streri, 2009). Second, the developmental trajectories of the subtests within each module were not uniform: some easier subtests matured early on in grade 2, but the more difficult ones did not reach plateau until grade 4 or even later. These developmental changes help draw a better and more comprehensive picture of the mathematical abilities of Chinese children in each grade. This will help maths teachers to more accurately estimate the developmental levels of different aspects of mathematical abilities and to identify the zone of proximal development(ZPD) (Vygotsky, 1986) of each, so as to adjust their paces of strategies of teaching to promote students' learning (Holton & Clarke, 2006).

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Reengineering Industry-Oriented Educational Programs at Senior High Schools in Taiwan

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ABSTRACT

The objective of this study was to assess attempts to bridge the gap between study and application in industry-oriented technology programs at senior high schools in Taiwan. This education reengineering project was implemented in an attempt to provide students with more immediate employability upon graduation. Teachers of professional subjects in senior high schools in Taiwan were the participants in this study. A total of 945 questionnaires were distributed using purposive sampling, of which 742 valid questionnaires were returned, a recovery rate of 78.50%. This study includes a literature review, discussions with experts, and a questionnaire. Following questionnaire development and distribution, results were analyzed using SPSS. Respondents that had taught for 21 years or more expressed greater approval of the project than those that had taught for 5 years or less. On the whole, teachers at senior high schools show a high level of approval for project implementation.

Keywords: technology education, senior high school, industry-oriented

INTRODUCTION

Technology education has played an important role in economic growth and industrial development in Taiwan. Taiwan's technology courses focus on pragmatism and practicality, enabling students to acquire expertise by doing, which equips them to enter their target industries immediately following graduation. Taiwan's technology education has produced a wealth of talent that has proven crucial to Taiwan's economic development. Chien (2017), for example, developed an integrated-STEM CO2 dragster design course using 3D printing technology for high school technology education. Students took a pre-engineering curriculum, then were assessed for differences in creativity, race forecast accuracy, and learning performance.

The Council for Economic Planning and Development made a population projection report in August of 2008 for the period from 2008 to 2056. The report predicted a continuing decline in the school-age population. This will affect resource allocation for all levels of education and exert a profound influence on future human resources (Pan, 2016). Investing in human capital requires a flexible education system that focuses on the innovative abilities and employability of young people. This study is motivated by the need to improve senior high school technology education.

In recent years, globalization and the international political environment have accelerated change in the industrial structure and production patterns in Taiwan. Taiwan's overall industrial structure is focused on high technology. Researching the strategies used in the reengineering project is thus a second motive behind this study.

The Industrial Development Bureau of the Ministry of Economic Affairs established a webpage to provide information on standards and evaluative measures for industry competencies. These standards serve as reference for students, training institutions, individuals, and corporations. This study is motivated to find effective strategies for coping with a changing market environment.

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Contribution of this paper to the literature

- This study surveyed attempts to reengineer industry-oriented education in senior high schools in Taiwan.
- This study investigated institutional adjustments, course activation, and employment promotion in industry-demand-oriented schools in Taiwan.
- The contribution of this study lies in its analysis of empirical data gathered after project implementation. The results provide reference for relevant project reviews, corrections in execution, and future plans. Properly implementing technology education projects is a key to successfully cultivating technology talent in Taiwan.

RESEARCH AIMS

This study investigated institutional adjustment, course activation, and employment promotion in industry-demand-oriented schools by examining the second phase of attempts to reengineer these programs. The results of this study provide theoretical and practical reference for project assessment and administrative applications.

LITERATURE REVIEW

Skills are the mainstay of vocational schools that form the foundation of industry in Taiwan. The united nations educational, scientific, and cultural organization (UNESCO) defines technology education as "those aspects of the educational process involving, in addition to general education, the study of technologies and related sciences and the acquisition of practical skills, attitudes, understanding and knowledge relating to occupation in various sectors of economic life" (Hollander & Mar, 2009). Chao, Tzeng, and Po (2017) combined hand-weaving techniques as a preliminary course with project-based learning to explore and research the problem solving process of aboriginal senior high school students during e-book production.

Low Birth Rate

The Japanese government was the first to use the term "declining birth rate" in 1990. Aging societies form when senior citizens exceed 7% of the population. Declining birth rates mean the overall population will fall, impacting various aspects of society such as social structure and economic development (Nomura & Koizumi, 2016).

According to the Organization for Economic Cooperation and Development (OECD), population structure equilibrium requires that each woman must give birth to 2.1 or more children. This number is referred to as the population replacement rate. The 2 in 2.1 refers to the number of children needed to replace the mother and father, whereas the 0.1 serves to cancel out the newborn fatality rate (Biswas, 2016).

Due to declining birth rates, the student population in Taiwan has been declining annually. Insufficient enrollment is forcing many schools to merge with other schools, undergo transformation, or even shut down.

Industry-Oriented Education Programs

The population structure of Taiwan presents low birth rates, aging, and heterogeneity. Low birth rates have already exerted a profound impact on domestic industrial, social, and educational development. The unemployment rate increased from 3.71% in January of 2015 to 4.08% in 2016. Structural issues are causing the unemployment rate to continue to rise (Salop, 1979). Many college students do not have an adequate understanding of their majors before they choose them. Consequently, few students actually go into industries relevant to their major, creating a gap in professional talent. A lack of career planning or lack of work experience prompt students to go back to school or delay their graduation. Skill and educational mismatches result in inadequate employability, resulting in an industry-academia gap.

According to the national development council of Taiwan, the service industry accounted for 63.15% of the GDP in 2016 and 59.17% of the employed population. This shows that the service industry has become the main body of economic activity in Taiwan and is the main source of job creation. The information and communications technology (ICT) industry has become the center of global production. In 2015, Taiwan was a global leader in the wafer foundry industry and the IC packaging industry; the output value of the former occupied 73.70% of global output, while the latter accounted for 51.80% of global output. In 2016, the overall manufacturing industry produced 30.16% of the GDP, while industry accounted for 35.04% of the GDP (Chien & Chen, 2017), as shown in **Table 1**.

Table 1. Overall economic indexes of Taiwan from 2013 to 2016

Dimensions	Unit	2013	2014	2015	2016
Economic growth rate	%	2.20	3.92	0.75	1.50
GNI per capita	Current value (USD)	22,526	23,308	23,131	23,284
Consumer price inflation rate	%	0.79	1.20	-0.31	1.40
Employment growth rate	%	0.99	1.02	1.08	0.62
Unemployment rate	%	4.18	3.96	3.78	3.92
Government expenditure as percentage of nominal GDP	%	19.27	18.74	17.63	17.98
Private expenditure as percentage of nominal GDP	%	71.79	70.76	69.25	70.02
Agriculture as percentage of nominal GDP (production approach)	%	1.69	1.80	1.70	1.82
Industry as percentage of nominal GDP (production approach)	%	33.46	34.79	35.13	35.04
Manufacturing as percentage of nominal GDP (production approach)	%	28.75	29.99	30.05	30.16
Service industry as percentage of nominal GDP (production approach)	%	64.85	63.41	63.17	63.15
Export of goods and services	Current value (USD)	3,574	3,721	3,400	3,336
Import of goods and services	Current value (USD)	3,098	3,172	2,716	2,696
Trade surplus of goods and services	Current value (USD)	476	549	684	640
As percentage of nominal GDP	%	9.30	10.36	12.89	12.09
Savings rate	%	32.00	32.95	34.41	34.04
Investment rate	%	21.46	21.20	20.27	20.22

Social diversity and dramatic changes in the industrial environment have resulted in a more specialized division of labor. While professional skills are obviously important, they do not indicate competitiveness. Industries must plan in advance and cultivate international mobility and global competence in students. In the face of global transformation and development of the digital economy, in-service talent will not necessarily have enough professional knowledge or skills to meet the needs of market development. To enhance competitiveness and assist in talent transformation, on-the-job training and development courses should be offered based on industry trends. Ongoing adjustments can be made to the course contents so as to reinforce talent resources in the industry (Pick & Nishida, 2015).

Development of Senior High Schools in Taiwan

The aim of vocational education in Taiwan is to teach professional knowledge, cultivate professional ethics, foster capable technical personnel, develop basic occupational skills, promote work attitudes such as dedication, teamwork, trustworthiness, enterprise, and diligence, improve humanistic and technological literacy, enrich personal lives, promote innovative thinking and adaptive abilities, and cultivate interest in further studies so as to lay the foundation for career development.

The Ministry of Education’s white paper on talent cultivation served as the blueprint for education in 2013 and 2014. It specified objectives for cultivating outstanding and dedicated teachers, bridging the gap between study and application, enhancing the global competitiveness of students, increasing the future productivity of students, and thereby achieving the cultivation of diverse and genuine talent and the creation of a happy and prosperous society.

In August of 2014, the Ministry of Education officially introduced twelve-year compulsory education, the Vocational School Law, which governs vocational high schools, and the Senior High School Act, which governs regular and comprehensive senior high schools, were combined to form the Senior High School Education Act. Vocational high schools were renamed senior high schools, and they are currently one of the foci of educational development. The Senior High School Education Act specifically states that senior high schools are one of the major types of schools and stipulates that they must establish programs and specializations in accordance with national development, society, industry, the attributes of the vocational discipline, and student careers (Ministry of Education, 2012).

After examining the vocational education and training of member states, the Organization for Economic Co-operation and Development (OECD) compiled the Skills Beyond School Synthesis Report to discuss the mechanisms of technical education institutions, present advantages and suggestions regarding each member state, and reveal that short-term higher education after secondary education is the main source of quality technical manpower in advanced countries (José-Luis, 2015; Winther-Jensen, 2015).

Article 9 in the Technology Education Act, which was promulgated and implemented in January of 2015, stimulates that “elementary schools, junior high schools and senior secondary schools shall provide vocational information and workplace-visit courses and career guidance courses, or incorporate vocational information, workplace visits, and career guidance into other courses to provide students with opportunities to learn about different vocational possibilities and establish a proper system of values pertaining to vocations and employment. The curriculum guidelines of elementary schools and junior high schools shall incorporate vocational knowledge and exploration content; senior secondary schools and junior high schools shall arrange visits to related businesses and industries for students" (Yu & Hu, 2017).

Coppola, Hiltz, and Rotter (2004) posited that students generally hope to learn from their teachers via direct instruction and interactive course content. This direct exchange must remain consistent throughout the course so that teachers and students can build and maintain a trusting relationship (Dorff, 2016).

Secondary education systems vary widely from country to country in terms of objectives, structure, resources and limitations, so it is difficult to compare the validity of these systems. The implementation of new teaching methods and teacher decisions are influenced by the expectations, beliefs and teaching styles of individual teachers (Vidic, 2017).

In the 1990s, e-learning was still in its preliminary stages. Most educators were skeptical of this new learning model. However, widespread technological development has made this mode of learning impossible to ignore. Teachers need to consider the learning effectiveness of their courses then design courses and learning activities that encourage student participation and interactions. E-learning has provided many new avenues for teachers to ensure that the educational experiences they offer are adequate in both quality and quantity (Mehta, Makani-Lim, Rajan, & Easter, 2017).

Schools thus began to plan professional courses that would bridge the gap between study and application. Teachers adjusted their teaching methods, striving to achieve academia-industry collaboration. Assessment methods now take different learning styles into account, promoting adaptive development in students and enhancing their employability in the hopes that they will obtain employment immediately following graduation.

Progress in big-data technology and technological innovation is rapidly altering the traditional structure of industry. Scope expansion and R&D are proceeding much faster in industry than in education. The lack of training and development of technical experts and vague talent cultivation mechanisms are affecting economic growth rates. These are currently core issues under discussion (Chen, 2010).

The virtual world (VW) is a virtual environment in which users can perform interactions using avatars. These avatars usually represent users as three-dimensional (3D) subjects that can freely interact within other avatars and world elements (subjects) in the virtual environment. A number of high-school students have found programming concepts more appealing when introduced via VR education platforms (Rico et al., 2011).

The Ministry of Education implemented the first phase of change in industry-oriented technology education between 2010 and 2012. The purpose of the project was to strengthen the development of pragmatic skills and fulfill the role of technical manpower cultivation. Ten strategies were formulated in the following five dimensions: system, teachers, courses and teaching, resources, and quality control. Preliminary success was achieved in the teaching environment, the strengthening of industry-academia connections, and the cultivation of quality professional talent (Grainger, Liz Bowen-Clewley, Maclean, & Matheson, 2016; Huang & Liao, 2016).

Changes in social ecology for educational development represent a two-way causal relationship (Cuadra & Moreno, 2005). A gap between study and application still exists in the demand from industry and the supply provided by educational institutions. Graduates often lack practical work experience, so skill and educational mismatches have long been a problem. In addition to providing new employees with pre-employment training, academia-industry collaboration should increase, and talent cultivation and industry practicum should be further promoted so students can prepare for future employment (Shyr, Liu, Liu, & Feng, 2017).

From 2013 to 2017, the Ministry of Education pooled resources from industry, government, and academia to formulate development strategies for technology education and implemented the second phase of change in industry-oriented technology education to cultivate the technical manpower needed for industrial development. The objective was to combine these resources, link them to the needs of industries and corporations, cultivate the technical manpower needed on various levels, and enhance the overall competitiveness of technology education (Wang, 2016).

The second phase of the project comprises three major constructs and nine strategies: institutional adjustment (project integration, discipline adjustment, and practical talent selection), course activation (flexible courses, equipment renewal, and practical skill upgrade), and employment promotion (employment convergence, innovative entrepreneurship, and combining certification with competency). The project funds were mainly aimed at renewing equipment for experiments in school subjects associated with manufacturing industries and key industries with technical labor shortage. The hope was for graduates to become immediately employable, provide the talent needed for industrial development, and enhance the overall competitiveness of technology education (Baumann & Winzar, 2016). The main points strategies are listed in **Table 2**.

Table 2. Reengineering industry-oriented technology education

Project		Execution strategy
Institutional adjustment	Project integration	(1) Gather competent authorities of industry, vocational training, and education for regular meetings to bridge the gap between study and application. (2) Set up a communication platform and develop mechanisms for talent cultivation and technical collaboration. (3) Make special laws for technology education.
	Discipline inventory	Assess the disciplines that schools offer and the total number of students they can enroll based on industry needs to balance the supply and demand of industrial talent.
	Practical talent selection	Increase the percentage of non-multiple-choice technical competency tests in college entrance exams.
Course activation	Flexible courses	Enhance flexible courses that converge with employment, workplace ethics, and practicum.
	Equipment renewal	Renew teaching equipment in three stages for convergence with industries with technical labor shortage.
	Practical skill upgrade	Arrange practicum for students on and off campus (domestically and abroad); recruit industry experts to assist in teaching and have teachers study at public and private institutions; reinforce practical teaching materials and teaching abilities.
Employment promotion	Employment convergence	(1) Offer industry-academia cultivation courses to help students prepare for employment. (2) Establish life and career progress files and convergence mechanisms to guide students in adaptive education, employment, and life development. (3) Formulate employment convergence, follow-up surveys, and counseling mechanisms for graduates.
	Innovative entrepreneurship	Promote a culture of innovative entrepreneurship on campus, assist local school research achievements to become innovative businesses and winning entries of international invention competitions in commercialization, and match local industries with the employment manpower that they need.
	Combining certification and competency	Enhance the employability of students.

METHODOLOGY

This study used literature review, questionnaire, and discussions with experts, adopting both qualitative and quantitative methods. The content structure of the formal questionnaire in this study comprised two parts. The first part collected demographic information, and the second part assessed strategies for reengineering industry-oriented technology education.

Research Process

We employed document analysis and a questionnaire. We collected, read, and analyzed government policy reports, official websites, literature, academic articles in foreign and domestic journals, magazines, video reports, and conference papers to construct a research framework and compile a questionnaire to serve as the research tool of our study.

Expert Meeting

Upon completion, the first draft of our questionnaire was reviewed by a group of twelve individuals, including industry experts, research experts in relevant fields, and the directors of practicum and internship programs at skills-based senior high schools. They examined the appropriateness of the wording in the questionnaire and provided suggestions for revision, thereby establishing the content validity of the research tool and providing crucial reference for the formal questionnaire.

Questionnaire Design

To fulfill the research objectives, the questionnaire was designed to collect data for professional competencies in 3 dimensions: (1) Institutional adjustment, (2) Course activation, (3) Employment promotion. A Likert scale was used to represent participant views, with 5-very important, 4-more important, 3-some-what important, 2-less important, and 1-least important rating factors related to their job performance.

The demographic information collected included gender, age, marital status, years of service, duties, and educational background. The questionnaire included 28 items divided into three dimensions: institutional adjustment, course activation, and employment promotion.

Research Design

The objective of the first stage was to investigate project implementation in senior high schools in Taiwan. Relevant domestic and foreign literature and reports were collected. The results were compiled for comprehensive generalization and analysis to confirm the study concepts and framework.

In the second stage, we met with experts to discuss the variables, constructs, and framework of the study and questionnaire development. Revisions were made based on their suggestions. The experts then examined the content validity of the questionnaire. The content was revised once more based on their opinions.

In the third stage, we adopted a quantitative approach, using document analysis and a questionnaire. The industry-demand-oriented questionnaire was developed based on expert opinions; it was then formally administered to samples representative of the population.

Participants

This study mainly examined attempts to reengineer industry-oriented technology education in senior high schools in Taiwan. Our participants were teachers of professional subjects in senior high schools in Taiwan. Below, we introduce the population and sampling principles.

Population

The sample population comprised the teachers of professional subjects in senior high schools in Taiwan.

Sampling methods

This study adopted purposive sampling. We contacted the principals, office directors, or teachers of various schools by phone and explained our research objectives and response methods to find schools willing to participate. We aimed for even distribution in northern, central, and southern Taiwan and finally decided on 21 senior high schools. A total of 945 questionnaires were distributed, with 742 valid questionnaires recovered. This represents a recovery rate of 78.50%.

Analysis

We selected samples based on their attributes and the locations of the schools. The formal questionnaire was conducted using purposive sampling. A total of 945 questionnaires were distributed, among which 742 valid questionnaires were recovered. The recovery rate was 78.50%. We then organized and coded questionnaire results for data entry. The data were then processed and analyzed using SPSS. We compiled descriptive statistics of demographic information to determine how responses differed according to relevant variables.

Each item in the questionnaire was a complete statement, and respondents were asked to indicate their level of agreement with the statements using a five-point Likert scale (1-strong disagreement, 2-disagreement, 3-neutral, 4-agreement, and 5-strong agreement).

Descriptive Analyses

The first part of the questionnaire collected the demographic information presented in **Table 3**. In terms of gender, 524 respondents were male and 218 respondents were female, which respectively accounted for 70.60% and 29.40% of the respondents. With regard to age, 94 respondents (12.70%) were 30 years old or younger; 256 respondents (34.50%) were between the ages of 31 and 40; 262 respondents (35.30%) were between the ages of 41 and 50; 122 respondents (16.40%) were between the ages of 51 and 60, and 8 respondents (1.10%) were 61 years old or older. In terms of marital status, 472 respondents (63.60%) were married, and 270 respondents (36.40%) were single. With regard to years of service at their schools, 168 respondents (22.60%) had served for 5 years or less, 170 respondents (22.90%) for 6 to 10 years, 142 respondents (19.10%) for 11 to 15 years, 94 respondents (12.70%) for 16 to 20 years, and 168 respondents (22.60%) for 21 years or more. With regard to their duties, 256 respondents (34.50%) also had administrative duties, whereas 486 respondents (65.50%) did not. In terms of educational background, 46 respondents (6.20%) had a junior college degree; 208 respondents (28.00%) had a bachelor's degree; 472 respondents (63.60%) had a master's degree, and 16 respondents (2.20%) had a doctoral degree. A total of 256 respondents (34.00%) expressed strong agreement with the claim that their school had actively participated in the project; 365 respondents (49.20%) agreed; 119 respondents (16.00%) had no opinion; 4 respondents (0.50%) indicated disagreement, and 2 respondents (0.30%) strongly disagreed.

Table 3. Demographic statistics

Background Variable	Gender			Age			Terms of marital status		
Category/Number of participants/Percentage	Male	524	70.60%	30 years old or younger	94	12.70%	married	472	63.60%
				31-40 years old	256	34.50%			
Total number of participants=587 Total percentage=100%	Female	218	29.40%	41-50 years old	262	35.30%	single	270	36.40%
				51-60 years old	122	16.40%			
				60 years old or older	8	1.10%			
Background Variable	**Duties**			**Years of service at their schools**			**Educational background**		
Category/Number of participants/Percentage	Administrative duties	256	34.50%	had served for 5 years or less	168	22.60%	junior college degree	46	6.20%
				for 6 to 10 years	170	22.90%	bachelor's degree	208	28.00%
Total number of participants=587 Total percentage=100%	did not	486	65.50%	for 11 to 15 years	142	19.10%	master's degree	472	63.60%
				for 16 to 20 years,	94	12.70%	doctoral degree	16	2.20%
				for 21 years or more	168	22.60%			

Table 4. Statistical analysis of questionnaire results (N=742)

Dimensions	Min	Max	Mean	SD
1. Institutional adjustment	**7.00**	**34.00**	**16.84**	**4.23**
1-1. Our school has established an effective communication platform for vocational and senior high schools, so administrative coordination is easier and more direct.	1	5	2.37	.77
1-2. Our school has concrete plans for academia-industry collaboration.	1	5	2.30	.78
1-3. Our school has established concrete technical exchange mechanisms to cultivate the talent required by the industry.	1	5	2.32	.77
1-4. Our school has a concrete understanding of industry demand and actively develops innovative planning mechanisms.	1	5	2.35	.78
1-6. The faculty at our school understands attempts to reengineer industry-oriented technology education and gives priority to key industries when granting subsidies.	1	5	2.45	.80
1-7. The faculty at our school understand the teacher appraisal (vocational high schools), faculty promotion (universities and colleges), and awards and grants mechanisms of the technology education system.	1	5	2.52	.85
1-8. The faculty at our school understand that the Technology Education Act stipulates that new teachers must have at least one year of practical work experience in an environment that is officially recognized by the central authority.	1	5	2.52	.89
2. Course activation	**10.00**	**48.00**	**21.96**	**5.89**
2-1. Our school plans professional courses based on industry demand.	1	5	2.34	.78
2-2. Our school encourages students to obtain professional and technical certificates based on industry demand.	1	5	1.95	.69
2-3. Our school has upgraded teaching equipment via the reengineering program for Industry-Oriented Technology Education.	1	5	2.04	.76
2-4. The teachers at our school coordinate the procured teaching equipment to best nurture the professional abilities in students that the industry needs.	1	5	2.04	.73
2-5. Our school invites industry experts to co-plan convergence courses.	1	5	2.29	.80
2-6. Our school plans courses and develops materials that are industry-demand-oriented.	1	5	2.28	.83
2-7. Our school plans industry-oriented practicum and featured courses.	1	5	2.23	.78
2-8. Our school focuses on industry demands so that students have practical abilities when they graduate.	1	5	2.38	.82
2-9. Our school hires industry experts to aid in teaching.	1	5	2.16	.85
2-10. The teachers currently teaching professional courses at our school have practical experience.	1	5	2.26	.80

Statistical Analyses

At least one respondent chose "strongly disagree," and at least one respondent chose "strongly agree," for each item so the minimum and maximum score values were 1 and 5 points, respectively. For the construct of institutional adjustment, the minimum and maximum scores were 7 and 34 points, respectively; in course activation, the minimum and maximum scores were 10 and 48 points; in employment promotion, the minimum and maximum scores were 10 and 50 points. Mean scores of the three constructs were 16.84, 21.96, and 23.59, respectively list in **Table 4**.

Table 4 (continued). Statistical analysis of questionnaire results (N=742)

Dimensions	Min	Max	Mean	SD
3. Employment promotion	**10.00**	**50.00**	**23.59**	**5.99**
3-1. The corporations that collaborate with our school give priority to our students when they are hiring.	1	5	2.29	.74
3-2. The corporations that collaborate with our school provide employment market information so that students understand industry needs.	1	5	2.26	.72
3-3. The corporations that collaborate with our school provide internship openings and plan for student practicum.	1	5	2.35	.80
3-4. Our school plans industry-oriented modular courses to provide students with immediate employability.	1	5	2.42	.81
3-5. Our school offers innovative entrepreneurship courses to cultivate innovative thinking in students.	1	5	2.37	.83
3-6. Our school assists winning entries of international invention competitions in commercialization.	1	5	2.70	.93
3-7. Our school holds campus recruiting events every year.	1	5	2.65	.99
3-8. Our school encourages students to obtain professional certificates corresponding to industry demands to benefit future employment.	1	5	2.04	.73
3-9. The number of students encouraged by our school to obtain professional certificates corresponding to industry demands is increasing annually.	1	5	2.15	.71
3-10. Our school holds various on-campus entrepreneurship promotion events and competitions to enhance the entrepreneurial skills of students.	1	5	2.36	.84

RESULTS

For institutional adjustment, items 1-7 and 1-8 presented the highest mean scores (M=2.52), while item 1-2 had the lowest mean score (M=2.30). For course activation, item 2-8 presented the highest mean score (M=2.38), whereas item 2-2 had the lowest mean score (M=1.95). For employment promotion, item 3-6 presented the highest mean score (M=2.70), whereas item 3-8 had the lowest mean score (M=2.04).

In terms of standard deviation, construct means and item means were all less than 3 points, which means that the senior high school teachers could identify with the items in the three constructs of the questionnaire. Only item 2-2 had a mean lower than 2 points, which shows a high degree of agreement in the remaining items.

For institutional adjustment, item 1-7 presented the highest standard deviation at 0.89, which means that the opinions of the 742 respondents were more divided with regard to this item. In contrast, item 1-1 had the lowest standard deviation at 0.77, which indicates greater consistency among the opinions of the 742 respondents in this item. For course activation, item 2-9 presented the highest standard deviation at 0.85, which means that the opinions of the 742 respondents were more divided with regard to this item. In contrast, item 2-2 had the lowest standard deviation at 0.69, which indicates greater consistency among the opinions of the 742 respondents in this item. For employment promotion, item 3-7 presented the highest standard deviation at 0.99, followed by item 3-6 with a standard deviation of 0.92. These results indicate that the opinions of the 742 respondents were more divided with regard to this item. In contrast, item 3-9 had the lowest standard deviation at 0.71, which indicates greater consistency among the opinions of the 742 respondents in this item.

No significant gender differences were found in the responses. In terms of standard deviation, construct means and item means were all less than 3 points, which suggests that the senior high school teachers could identify with the items in all three constructs of the questionnaire. Only item 2-2 had a mean lower than 2 points, which shows a high degree of agreement in the remaining items. On the whole, responses regarding feelings about reengineering project implementation in technology education varied significantly with the age of the respondent. We thus applied Scheffé's method but could not distinguish the cut off for differences. Responses regarding reengineering project implementation in technology education also varied significantly with years of service. We thus applied Scheffé's method and found that respondents that had served for 21 years or more (M=2.38) presented a significantly higher mean score than respondents that that had served for 5 years or less (M=2.20).

In **Table 5**, for institutional adjustment, the mean score presented by male respondents was 2.39, and the standard deviation was 0.62. In contrast, the mean score presented by female respondents was 2.44, and the standard deviation was 0.57. The F statistic of institutional adjustment was significant (0.64>0.05), which means that the data should be interpreted under the assumption of equal variance. The variance test result had greater significance than 0.5, whereas the Levene test of equal variance did not reach that level of significance. The F statistic was significant (0.27>0.05), which suggests that there were no significant differences (consistent) in the variances (divergence) of the male and female samples. We could thus assume equal variance. The results showed that $t(740) = -1.09$, $p>0.05$, and 95% CI[-1.02, 0.3]. The two-tailed significance was 0.27>0.05, which accepts H0 and indicates

Table 5. Independent t test results regarding gender

Dimensions	**Analysis of variance**					
	Gender	Sample	M	SD	t	p-value
Institutional adjustment	Male	524	2.39	.62	-1.09	.27
	Female	218	2.44	.57		
Course activation	Male	524	2.19	.61	-.42	.67
	Female	218	2.21	.53		
Employment promotion	Male	524	2.36	.62	-.26	.79
	Female	218	2.37	.54		

no significant differences between the responses made by the male and female respondents in institutional adjustment.

For course activation, the mean score presented by male respondents was 2.19, and the standard deviation was 0.61. In contrast, the mean score presented by female respondents was 2.21, and the standard deviation was 0.53. The F statistic for course activation was significant (0.11>0.05), and the variance test result was significantly greater than 0.5. The F statistic obtained from a Levene test of equal variance was significant (2.61>0.05), which means no significant differences (consistent) in the variances (divergence) of the male and female samples. We could thus assume equal variance. The results showed that t(740)=-0.42, p>0.05, and 95% CI[-1.08, 0.73]. The two-tailed significance was 0.67>0.05, which accepts H0 and indicates no significant differences between the responses made by the male and female respondents in course activation.

For employment promotion, the mean score presented by male respondents was 2.36, and the standard deviation was 0.62. In contrast, the mean score presented by female respondents was 2.37, and the standard deviation was 0.54. The F statistic of employment promotion was significant (0.11 >0.05), which means no significant differences (consistent) in the variances (divergence) of the male and female samples. We could thus assume equal variance. The results showed that t(740)=-0.26, p>0.05, and 95% CI[-1.03, 0.82]. The two-tailed significance was 0.79>0.05, which accepts H0 and indicates no significant differences between the responses made by the male and female respondents in employment promotion.

As shown in **Table 5**, the overall mean of scores given by women in the three dimensions (institutional adjustment, course activation, and employment promotion) were higher than that of scores given by men, which indicates that women were more likely to approve of the educational program changes than men.

The results in **Table 6** indicate significant differences among the responses made by different age groups on overall (F=4.27, p<.05). However, application of Scheffé’s method could not distinguish the differences. The different age groups displayed no significant differences on the institutional adjustment level (F=2.30, p>.05). The different age groups displayed significant differences on the course activation level (F=4.06, p<.05). However, application of Scheffé’s method could not distinguish the differences. The different age groups displayed no significant differences on the employment promotion level (F=4.88, p<.01). Scheffé’s method showed that respondents between the ages of 41 and 50 (M=2.52) presented a significantly higher mean score in employment promotion than respondents that were 61 years or older (M=2.10) and those that were 30 years old or younger (M=2.15).

Table 6. Summary table of analysis of variance with regard to age on different factor levels

Dimensions	Analysis of variance						
Factor level	**Age**	**Sample**	**M**	**SD**	**F**	**p**	**Scheffé**
Institutional adjustment	(1) 30 years old or younger	94	2.31	.56	2.30	.06	
	(2) 31-40 years old	256	2.34	.60			
	(3) 41-50 years old	263	2.47	.58			
	(4) 51-60 years old	121	2.45	.62			
	(5) 60 years old or older	8	2.52	.98			
Course activation	(1) 30 years old or younger	94	2.05	.53	4.06**	.00	(3)>(1)
	(2) 31-40 years old	256	2.13	.55			
	(3) 41-50 years old	263	2.29	.60			
	(4) 51-60 years old	121	2.25	.61			
	(5) 60 years old or older	8	2.14	1.06			
Employment promotion	(1) 30 years old or younger	94	2.15	.53	4.88**	.00	
	(2) 31-40 years old	256	2.34	.61			
	(3) 41-50 years old	263	2.45	.60			
	(4) 51-60 years old	121	2.38	.58			
	(5) 60 years old or older	8	2.10	.74			
Overall	(1) 30 years old or younger	94	2.16	.48	4.27**	.00	
	(2) 31-40 years old	256	2.26	.54			
	(3) 41-50 years old	263	2.40	.54			
	(4) 51-60 years old	121	2.35	.55			
	(5) 60 years old or older	8	2.22	.85			

N=742; *p< .05; **p< .01

Table 7. Summary table of analysis of variance with regard to years of service

Dimensions	Analysis of variance						
Factor level	**Years of service**	**Sample**	**M**	**SD**	**F**	**P**	**Scheffé**
Institutional adjustment	(1) 5 years or less	168	2.33	.59	2.75*	.027	
	(2) 6-10 years	170	2.4	.66			
	(3)11-15 years	142	2.31	.56			
	(4) 16-20 years	94	2.43	.57			
	(5) 21 years or more	168	2.5	.61			
Course activation	(1) 5 years or less	168	2.09	.57	2.95*	.019	
	(2) 6-10 years	170	2.21	.60			
	(3)11-15 years	142	2.15	.56			
	(4) 16-20 years	94	2.29	.61			
	(5) 21 years or more	168	2.28	.60			
Employment promotion	(1) 5 years or less	168	2.22	.57	3.33*	.010	
	(2) 6-10 years	170	2.40	.60			
	(3)11-15 years	142	2.35	.60			
	(4) 16-20 years	94	2.46	.66			
	(5) 21 years or more	168	2.41	.57			
Overall	(1) 5 years or less	168	2.20	.53	3.36*	.010	(5)>(1)
	(2) 6-10 years	170	2.34	.57			
	(3)11-15 years	142	2.27	.52			
	(4) 16-20 years	94	2.39	.56			
	(5) 21 years or more	168	2.38	.54			

N=742; *p< .05; **p< .01

The results in Table 7 indicate significant differences overall among respondents that had served for different periods of time (F=3.36, p<.05). We thus applied Scheffé's method and found that respondents that had served for 21 years or more (M=2.38) presented a significantly higher mean score on the overall level than respondents that that had served for 5 years or less (M=2.20). Responses on the institutional adjustment level varied significantly with years of service (F=2.75, p<.05), as did those on the course activation level (F=2.95, p<.05) and the employment promotion level (F=3.33, p<.05). However, application of Scheffé's method on all three levels could not distinguish the differences.

DISCUSSIONS

Scheffé's method showed that respondents between the ages of 41 and 50 presented a significantly higher mean score in employment promotion than respondents that were 61 years or older and those that were 30 years old or younger.

On the whole, responses regarding attempts to reengineer technology education programs varied significantly with the age of the respondent. Results derived from Scheffé's method suggest that respondents that had served for 21 years or more presented a significantly higher mean score than respondents that that had served for 5 years or less.

Overall results, the overall mean of scores given by women for institutional adjustment, course activation, and employment promotion dimensions were higher than the scores given by men, which indicates that women were more likely to approve of the reengineering project than men.

Teachers play a very important role in educational activities, but they often don't know much about industry-oriented education and employment promotion. Therefore, in order to help students cultivate innovative thinking and improve their employability, both the government and the school must pay attention to the practical experience of teaching staff.

Schools must build channels for students to communicate and cooperate with enterprises. Corporations that collaborate with schools must provide employment market information so that students understand industry needs, and so schools can provide internship openings and plan for student practicum. Only with cooperation between schools and industry can the value of technology be maximized.

CONCLUSIONS

The objective of this study was to explore teacher's opionions about attempts to reengineer technology education programs at senior high schools in Taiwan. Technical and vocational education must work in tandem with industrial practice. The second phase for reengineering industry-oriented technology education ran from 2013 to 2017. The project appeared to have a positive impact on technical and vocational schools. In the second phase of the project, strategies for flexible courses, equipment renewal, practical skill upgrades, and employment convergence were implemented because they are directly associated with the cultivation of practical abilities needed in industry. The implementation of the reengineering project allowed technical and vocational schools in Taiwan have become more effective in cultivating professional skills in students and narrowing the industry-academia gap. We drew conclusions based on the analysis of our empirical results and formulated suggestions based on said conclusions to provide reference to schools, teachers, and administrative agencies in education.

The implementation of the education reengineering project helped to enhance the employability of students. However, current student tracking systems still lack complete data and information transparency. The implementation of this project also promoted knowledge-action integration and enhanced the practical abilities of teachers and students at technical and vocational schools. However, corporations should take some responsibility for talent cultivation; when graduates first enter corporations, vocational training and counseling can help novices immediately get on track for professional development.

1. In terms of institutional adjustment, the government should establish a cross-organization team to integrate government, industry, and school resources. Cultivation of industrial talent in Taiwan relies on institutions successfully implementing the regulations laid out in the Technical and Vocational Education Act.
2. In terms of course activation, technical and vocational high schools and colleges should develop curricula in collaboration with industry. Flexible course design and the connection and planning of interdisciplinary courses vary by school and require further improvement.
3. In terms of employment promotion, the greatest challenge at present is that many students are not willing to remain in the technology industry because they have other plans for their future.

The government of Taiwan is actively following a southbound policy, and many countries in Southeast Asia are in the take-off stage of economic growth. Technical and vocational education in Taiwan has cultivated considerable talent, and students in this education system have gained impressive achievements in various international competitions. We suggest that the government promote these successful experiences to countries throughout Southeast Asia and assist nearby countries in developing their national industry. This will prompt more solid development in Taiwan's technical and vocational education, promoting people-to-people diplomacy, thereby increasing the international influence of Taiwan's technical and vocational education system.

This study used both theoretical and practical perspectives to examine the implementation of the second phase for reengineering industry-oriented technology education in senior high schools in Taiwan. The results of this study provide reference for project assessment and administrative applications.

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Effect of Different Instructional Methods on Students' Conceptual Change Regarding Electrical Resistance as Viewed from a Synthesized Theoretical Framework

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ABSTRACT

This study sought to investigate the effect of different instructional methods on students' conceptual change and to explore junior secondary school students' misconceptions about electrical resistance. Quasi-experimental design was employed to compare whether or not there are significant differences among various teaching methods. The participants (165 junior secondary school students in China) were enrolled in three classes instructed by the same physics teacher. This study was carried out in a synthesized theoretical framework and found that the inquiry teaching method was effective in learning about resistance. Meanwhile, didactic learning supplemented with mathematical deduction was better in developing conceptual understanding of equivalent resistance. The crux of the matter is not whether the instructional method is traditional, but whether it brings mental disequilibrium and achieves conceptual framework shift. The findings distinguished a teaching strategy rooted in cognitive psychology from a strategy derived from physics itself. It also demonstrated the importance for teachers to use strategies derived from physics to accomplish students' conceptual framework shift. Meanwhile, this study investigated the opinions held by students and found a number which had not previously been reported. Therefore, it is essential for physics teachers to probe students' misunderstanding of a certain physics concept and design corresponding teaching method to accomplish students' conceptual framework shift.

Keywords: conceptual change, electrical resistance, instructional method, metacognition

INTRODUCTION

In recent years, there have been great interests in students' conceptual understanding in science. A vast body of researches have been conducted on students' misconceptions in many areas of science (e.g., Borges & Gilbert, 1999; Gönen 2008; Park & Kim, 1998; Viard & Khantine-Langlois, 2001). Previous research pointed out that misconceptions could develop both from external and internal sources (Bar, 1989; Bar & Travis, 1991; Ross & Shuell, 1993). It was seen as something that developed from TV and other media, peers, and family, in addition to the classroom inside, often from poor instruction (Gomez-Zwiep, 2008). In this paper we focus on students' difficulties dealing with the concept of electrical resistance. Although extensive researches have investigated students' difficulties in understanding the behavior of a simple electric circuit (Küçüközer & Kocakülah, 2008; Shepardson & Moje, 1994; Stockmayer & Treagust, 1994), there is few documents explore students' misconceptions about electrical resistance. McDermott and Schaffer (1992) first noted a tendency of students to focus on number of circuit elements rather than on configuration in an electric circuit when a resistance was added in parallel to a network. Students

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Contribution of this paper to the literature

- This is the first article to investigate the effect of different instructional methods on students' conceptual change in the context of China.
- The results indicate didactic learning supplemented with mathematical deduction was better in developing conceptual understanding of equivalent resistance.
- The crux of the matter is not whether the instructional method is traditional, but whether it brings mental disequilibrium and achieves conceptual framework shift.

often have not been explicitly confronted with the fact that the equivalent resistance decreases with the addition of the element. Viard and Khantine-Langlois (2001) pointed out that the existence of the common term of resistance in the everyday language could be the root difficulties in the understanding of the working of electric circuits for students. In the case of Chinese students, their understanding of electrical resistance is even more incorrect, and it came from three different dimensions: firstly, as the electrical resistance is translated into Chinese language , it is endowed with additional meaning; secondly, the electrical resistance is a complex concept, even some teachers are confused with electrical resistance because it is defined neither by law of resistance nor by Ohm's law, actually it is defined by the deformation formula of Ohm's law; thirdly, when it comes to such conceptions like resistance, density, velocity, capacitance and so on, Chinese students' fixed way of thinking is to understand physical quantity's meaning by means of mathematical formula. Therefore, these students persist in the consistency between mathematics and physics, especially mathematics is considered to be the foundation of physics. As students' misconceptions about electrical resistance are too stubborn to change, Chinese physics teachers are used to say the resistance is an attribute of the object to emphasize its invariance, i.e., it is not changed according to the voltages across the resistor and the currents it carries (though it is tenable only for ohmic materials and the conductor's resistance will change according to its cross sectional area, length and temperature).

In this study, taking the traditional teaching method of electrical resistance as example, we investigate the effectiveness of different inquiry teaching method in Chinese secondary school students. As the traditional Chinese cultural is concerned, secondary school students seldom query their teachers, not to mention the textbooks, they are always ready to accept the concept that teacher should tell them. Unfortunately, though they are ready to accept the knowledge, some of them just can not change their misconceptions. They can recite the definition of a scientific concept fluently. But do not be aware of the differences between the scientific concept and their own everyday concept. Thus his usage of it is not always do execution. This study aims to investigate what opinions have been held by students about the electrical resistance and whether inquiry teaching method has good results in comparison with the traditional instruction so can contribute to the conceptual change theory.

LITERATURE REVIEW

Misconceptions are rooted in students' everyday experience and thus too stubborn to change. Some researchers have shown that traditional teaching approaches have not been influential as much as we expected on changing students' misconceptions (Çepni & Keles, 2006; Gomez-Zwiep 2008). According to the conceptual change model (Posner, Strike, Hewson, & Gertzog, 1982; Strike & Posner 1992), students' misconceptions are unshakable to change because their misconceptions are not merely false beliefs but instead, students possess their own cognitive support groups and defense mechanisms. Thus when a discrepant event which provided students novel evidence to contradict their misconceptions was presented, they could just ignore it. They either made an explanation in accordance with their misconceptions or modified the "protective belt" and preserved the "hard core" of their misconceptions. Meanwhile, others argued that students were more apt to accept contradictive evidence obtained by an integrated science inquiry skill (controlling variables) than by a basic science inquiry skill (observation), thus could be successful in conceptual change (Park & Kim, 1998).

To carry out our research, we must be conscious of our epistemological presuppositions firstly. The experience of teaching physics history for undergraduates made the first author to be a believer of Kuhn and Lakatos' theory. Posner et al. (1982) likened the change in individuals' conceptions to changes in the knowledge of scientific communities during a paradigm shift (Kuhn, 1970). Thus made an explanation of the difficultness for a physics teacher to interpret that magnetic phenomenon is electrical in nature to his/her students. Mankind has spent hundreds of years on understanding it, and for individual, it is desired to be fulfilled in a couple of days. If it were not for abandoning his existing misconceptions system, this would not happen. On the contrary to abandoning their existing beliefs, students used to modify the "protective belt" and preserve the "hard core" of their misconceptions, the prototype of students' behavior can be found in Lakatos' scientific research programme model. Lakatos (1994) explained that experimental results in themselves were not sufficient to eliminate a hard core, and that any theory could be insulated from refuting results by adjusting the protective belt, either by suggesting auxiliary hypotheses to modifying initial conditions or by giving suitable reinterpretation of its terms. As a consequence, students are content with the fact that they do make some changes after formal education. When they deal with a problem in physics and have to make a decision, in some cases, compared with their original ideas, they use the more sophisticated conceptions to solve the problem, and in other cases they come back to the original ideas and fail to make a correct response. To walk away from this teaching puzzle, it is necessary to pay attention to Piaget's theory of cognitive development. Researches have shown that cognitive conflict must be generated in students' minds to challenge their misconceptions about natural phenomena. Various methods or strategies were suggested by science educators to help students achieve mental disequilibrium, for instance, hands-on, minds-on activities and questioning (Gomez-Zwiep, 2008), concept mapping (Horton et al., 1993; Roth & Roychoudhury, 1993), and metacognition (Georghiades, 2004; White & Gunstone, 1989). Compared to the Conceptual Change Model (Posner et al., 1982; Strike & Posner, 1992), Yuruk, Beeth, and Andersen (2009) also put forward metacognition as another theoretical framework to explain the nature of the change in learners' alternative conception.

The above discussions made the authors' epistemological presuppositions distinctly. According to Kuhn and Lakatos' theory, traditional instruction with simply presenting students the correct information is far from sufficient to guarantee students' conceptual change. It requires subversive evolution in students' inward world to achieve conceptual framework shift. As viewed from the physics history, the evolution of scientific concept was not accomplish at one stroke, instead, it is always transited from adjusting the protective belt to modify the hard core. Even the adjusting of protective belt made the concept more sophisticated. Thus to some extent, it can be viewed as scientific concept though it is not the concept possessed by scientists. Most of the successful methods in conceptual change include initiating some type of cognitive conflict within the students' inner beliefs and the contrary evidence presented by formal instruction. In addition, to facilitate students' concept learning, metaconceptual knowledge and metaconceptual processes also should be considered in the teaching design. In other words, we believed it is necessary to take advantage of both the CCM and the metacognition to explain the nature of students' conceptual change in science. Therefore, the study of Chinese students' conceptual change regarding electrical resistance was carried out in a synthesized theoretical framework.

The Chinese educational system was designed as pre-school, primary school, junior secondary school, senior high school and university. Pre-school education is given to children between 3-6 ages. Although it is not compulsory, these pre-schools extended all over the country. Parents select the kindergarden carefully to make sure their children will win at the starting line. Primary school is compulsory and it continues 6 years (between 6-12 ages), science lessons are given from 3th to 6th grades with two or five lessons per week. Chinese, English, mathematics and science are set to be core curriculums. Junior secondary school is also compulsory and it continues 3 years (between 12-15 ages). During this period, physics is taught both 8th and 9th grades with four lessons per week. Senior high school is not compulsory and it continues 3 years (between 15-18 ages). All the senior high school students have to study physics in the first year to get 6 credits, and it is the minimum requirement for graduation. Though they are not compelled to choose and study other physics units to get more credits, most of them insist on studying optional physics units in the following two years. Otherwise they will not be allowed to register for science department or engineering department in universities.

Given that physics pervades modern civilization, the life of a student who persistently performs poorly in physics achievement can become a nightmare either to himself or to the society. Actually, most Chinese students failed in science learning at the very start, which put them at a serious disadvantage. Under the circumstances, in recent years, there has a tendency of transformation from elite education to quality education to realize the goal of "Science for All". The policymaker introduced the constructivist perspective and inquiry teaching to science teachers as a magic drug. Ministry of education of the people's republic of China (2001) emphasized that "inquiry" is the core of this time's physics curriculum reformation (p.32). However, the insufficient preparations of theory, as well as the strong influence of the traditional teaching methods, making many science teachers come back to their didactic teaching. In their opinion, the didactic lecturing is the best teaching method. For the lack of pedagogical knowledge, they can not employ inquiry learning and cooperative learning perfectly in their classrooms, and they don't think it is a matter. Also as the limited class period they seldom do demonstrative experiment, not to mention permitting students to do laboratory experiment. In current teaching practices, the nature phenomena and experimental results are described to students. For the pressure of exam-oriented education, they generally finished the concept teaching in a hurry, and then set aside lots of time to do numerous exercises. On the one hand, both students and teachers make efforts to be successful, and on the other hand, the losers of science learning are produced from their school continuously.

METHODS AND PROCEDURES

Research Design

The effect of different instructional methods on students' conceptual change was investigated in this study. Two quasi-experiments were employed to statistically compare students' conceptual understanding of electrical resistance.

The design of these two quasi-experiments is based on the diversity of students' misconceptions about electrical resistance. Before the instructional interventions, we distinguished two categories of students' misconceptions:

Category 1 Firstly, some students are inclined to treat electrical resistance as an attribute of the electrical circuit, therefore, once the status of the electric circuit (e.g., the voltage across the conductor or the current in the conductor) changed, they believe the resistance of the conductor changed consistently. This kind of misconception can be changed through the teaching of Ohm's law. The first quasi-experimental design was applied to conceptual change in cases of this kind. The traditional instruction is lecturing format supplemented with demonstrations. Recently, the physics curriculum standard of the full-time compulsory education in China (2001) suggests students to apply control variate method to design an inquiry-based laboratory experiment in learning of Ohm's law. Though controlling variables is an integrated skill which inquiry teaching emphasizes, we don't think it is the best inquiry skill to conceptual change regarding electrical resistance. In control variate method, the fact that the electrical resistance remains constant is implicit. In other words, the cognitive conflict between the electrical resistance as a constant and the misconception that the resistance is relevant to the voltage or current is hidden. Students pay efforts to make a feasible experimental design or comprehend their teachers' design, be busy in replacing the electrical resistance, shifting sliding rheostat to get voltage and current value which are convenient for comparison. The above activities distract their attention and lead to their disregard of the electrical resistance. When the experiment is finished, they get a formula as a result and try to understand electrical resistance with this mathematical equation. Compared with control variate method, image method is easy to understand. In this instance, students manipulate a simple circuit to get voltage and current value, and then draw a current voltage diagram. In the diagram, electrical resistance is the slope of volt-ampere characteristic curve, it is a constant. As the voltage and current change, the electrical resistance remains the same, thus the conceptual conflict between the scientific concept and students misconceptions is explicit. Therefore, we infer that the image method is the best inquiry teaching design.

Category 2 Secondly, they often think that the resistance is an increasing function of the size of the conductor and in particular of its cross section (Johnstone & Mughol, 1978). When a resistor was added in parallel to another, the equivalent resistance increased. This kind of misconceptions can be changed through the teaching of "the equivalent resistance of the circuit". The second quasi-experimental design was applied to conceptual change in cases of this kind. In traditional teaching, the knowledge of equivalent resistance was explained by the teacher mainly in lecturing format without any hands-on experiments or demonstrations. Because in Chinese physics textbooks, the section of "Ohm's law" is followed by "the equivalent resistance of the circuit" immediately, as much time has been spent in the inquiry teaching of Ohm's law, it is unnecessary to make another hands-on experiment or demonstration. The lecturing format contains two typical conditions: the first teaching method is language description; teachers often liken the equivalent resistance to the school gate. In series circuit, equivalent resistance increases when two resistors are connected end-to-end, it is similar to when you squeeze through the narrow passage and find there is another passage in front of you, which make you exhausted. In parallel circuit, equivalent resistance decreases with two resistors connected in parallel, it is similar to build a new passage, so we can get through more easily. The second teaching method is getting the equivalent resistance equation of series circuit or parallel circuit by logic reasoning and mathematical deduction. Compare with the lecturing style, inquiry teaching with students' laboratory experiments was unusual. We were hesitating to presuppose which method would work best among these teaching methods. Each individual student has his/her own personality. Language description method may lead to the maximal conflict in students' who are good at imagination. While the logic reasoning and mathematical deduction method may lead to the largest conflict in students' who are good at logical thinking and mathematics. Meanwhile, the inquiry method may lead to the supreme conflict in students who are fond of verifying things by hands-on activities and observation.

Metaconceptual Knowledge and Processes

Yuruk et al. (2009) pointed out that metaconceptual knowledge and processes can be classified into four components: metaconceptual knowledge, metaconceptual awareness, metaconceptual monitoring, and metaconceptual evaluation. In Chinese physics curriculum standard of the full-time compulsory education (2001), science inquiry is resolved to seven components, such as "raising a question", "guessing and hypothesizing", "drawing up a plan and designing the experiment", "carrying out the experiment and gathering the evidence", "analyzing and proving", "evaluating", "communicating and cooperating". The first component "raising a question" requires students to pose a question either by their daily life or by the observation of an experiment. Students are dissatisfied with their existing beliefs as it is too crude to explain the natural phenomenon. They are aware of there must be some changes regarding their conceptual framework in order to answer the question they proposed. In this component they had to recognize the elements of their existing conceptual structure which has been defined by Yuruk et al. (2009) as metaconceptual awareness. The second component "guessing and hypothesizing" requires students to put forward hypothesis based on their experience and prior knowledge. Yuruk et al. (2009) suggested that the metaconceptual knowledge can be defined to include one's stable and statable knowledge about concept learning and the factors influencing concept formation. To be explicit, Yuruk et al. (2009) made a further explanation that the metaconceptual knowledge is something acquired through experience and stored in the memory. As to pose their hypothesis, students need to not only retrieve their experience but also make reference to their past conceptual structure. It is clear that the former represents students' metaconceptual knowledge and the latter represents their metaconceptual awareness. The third component "drawing up a plan and designing the experiment" requires students to try to consider the main factors which influence the issue, then use control variate method to design an experimental program. In this step, they should make reference to their past conceptual framework to decide which factors would be primary to the issue. This is a manifestation of metaconceptual awareness. In addition, they have to make clear the known and unknown things, the methods, materials and procedures be about to employ in the experiment. In other words, to formulate a reasonable program, they had to generate information about their cognitive state or thinking process which was defined as metaconceptual monitoring by Yuruk et al. (2009). The fourth component "carrying out the experiment and gathering the evidence" requires students to obtain data from observation and experiment. As students are monitoring information coming from the experiment, checking the consistency between the existing conception and new information, this stage can be classified as metaconceptual monitoring. The fifth component "analyzing and proving" demands students to make a brief comparison between the information gathered from the experiment and from other sources, draw conclusions from cause-and-effect relationships, defend his opinions with evidence and debate with others who have different opinions. Students are often organized as groups to discuss the different opinions, make impartial assessment to his and others opinions. By conducting a simple comparison and drawing the conclusion, he monitors the consistency between the existing beliefs and new conception. By discussing opinions coming from other students, he monitors his and others conceptual change. By making assessment on others opinions, he evaluates the validity and limitations on competing conceptions impartially. Students' status of metaconceptual monitoring and metaconceptual evaluation is clearly. The sixth component "evaluating" demands students to consider whether their experimental results and conclusions are contradictory to their prior knowledge. Meanwhile pay attention to the defects of their experimental plan, finding new questions which should be handled later. The last component of science inquiry is "communicating and cooperating", which requires students to respect others opinions during the cooperative learning, analyze the differences between his and others opinions. Both the sixth and the last component of science inquiry are metaconceptual monitoring and evaluation processes.

In the last three components of science inquiry, as long as student's opinion is proved to be false in the group debate or classroom discussions, he is assumed to admit his error and abandon it immediately. However, it should be pointed out that in these steps, students' status of abandoning their misconceptions and changing to the scientific conception is an idealized outcome of concept learning. Though the metaconceptual knowledge and metaconceptual processes are integrated to the science inquiry properly, it maybe not sufficient for lots of students to eliminate the "hard core" of their misconceptions.

Participants

This study took place in a public junior secondary school located in an urban school district in Zhengzhou of China. Four-fifths of the students in this school come from the rural migrant worker's family and the socioeconomic status of most families was in lower-income group. It represents the typical student situation in public junior secondary schools in large cities of China. The participants (165 junior secondary school students) were enrolled in three classes taught by the same science teacher, they were randomly assigned to each class by a computer scheduling program at the beginning of 7th grade and rearranged according to his or her academic performance at the end of 7th grade. The classes' arithmetic means on physics term examination of the first semester of 8th grade had no significant difference. The teacher who voluntarily participated in this research had more than 5 years of experience in physics teaching and was familiar with the inquiry teaching theory as she graduated from a normal university after year 2002.

In Chinese educational system, all the junior secondary school students are compelled to study physics course at the beginning of 8th grade, the electrical resistance is taught at the beginning of the second semester. Teaching approaches (inquiry teaching or traditional instruction) were randomly assigned by the researchers to each classroom.

Table 1. Five items used in the pre-test

Item 1: When an electric hand torch has been used for a long time, the dry battery's voltage decreases, the bulb light is dimming. It means the resistance of bulb: (a) is constant; (b) increases; (c) decreases; (d) other Because,
Item 2: When we shift the slide rheostat to enlarge the circuit current, the bulb light grows brighter. It means the resistance of the bulb: (a) is constant; (b) increases; (c) decreases; (d) other Because,
Item 3: Two 5Ω nichrome wire resistors are connected in series to each other, the total resistance is: Because,
Item 4: Two 5Ω nichrome wire resistors are connected in parallel to each other, the total resistance is ： Because,
Item 5: When a wire was elongated four times, how its resistance changed? (a) is constant; (b) increases; (c) decreases; (d) other Because,

In the first quasi-experiment, students in class A (comparison group) were instructed by the traditional methods while students in the experimental group (class B, class C) were exposed to inquiry circumstances. There were 54 students in class A and 46 of them were identified to have misconceptions (category 1) in the pre-test. To be more precise, the comparison group was made up of students who have misconceptions. There were 56 students in class B and 50 of them were identified to have misconceptions of category 1, students who had misconceptions constituted the first experiment group taught by inquiry method using control variables. There were 55 students in class C, 50 students who had misconceptions (category 1) were chosen to be the second experiment group taught by inquiry method using image skill. In the second quasi-experiment, students in class A were exposed to inquiry circumstances while students in class B and class C were instructed by the different traditional instructional methods.

Typically, students are instructed by the physics teacher and led to build an understanding of Ohm's law for themselves in the first 45-minute lecture. In the second 45-minute lecture, a few minutes are spent to get students familiar with the formula of Ohm's law and its deformation formula (Otherwise, some students may failed in solving the problems in post-test 1 not according to they have not a scientific comprehension of resistance but due to they can't employ the formula into calculation. Meanwhile, the formula teaching is not involve with the decision whether the electrical resistance is constant), then they are given 10 minutes to solve the problems in post-test 1, after that they participate in the discussion and solve other problems. The third and fourth lectures usually designed to review the concept of resistance and Ohm's law, and some complicated problems are introduced to students. In the first lecture of the next week, students are involved in the concept learning of equivalent resistance. At the first 10 minutes of the second lecture, they are demanded to complete the post-test 2, the rest time are used to solve various equivalent resistance problems. Pre-test and Post-test all done in the lecture. If they are arranged to be homework, students may get answers from consulting reference book or check their answers with classmates before they hand in it.

Data Source and Analysis

Pre-test In order to probe the manifestation of students' misconceptions about electrical resistance, a paper and pencil test consisting of 5 open-ended questions was developed. The prototype of this instrument can be seen in Park and Kim's (1998), similar design also can be seen in Gönen's study (2008). Furthermore, a group of physics educators and physics teachers checked the test for validity and then confirmed the content validity of the instrument. Pre-test was completed by students in the first physics lecture of the second semester of 8th grade. The test items in the pre-test are shown in **Table 1**. Item 1 and 2 were designed to identify students' misconceptions about electrical resistance of category 1. The rest were designed to identify students' misconceptions about electrical resistance of category 2. According to the different type of inferential statistics used in quasi-experimental treatment, the first two items were analyzed under the following categories suggested by Abraham et al. (1994), i.e., sound understanding, partial understanding, and partial understanding with specific misconception, specific misconceptions and no understanding.

Student's achievement score was determined by the following method. Sound understanding was recorded as 4, partial understanding was recorded as 2, partial understanding with specific misconception was scored with 1, specific misconception and no understanding was scored with zero. There is no score of 3 was given for items 1 and 2, this scoring approach was used to show the big disparity between sound understanding and partial understanding. Though students with partial understanding didn't display some kind of misconceptions, they also

Exercise 1. The resistance of a conductor is 4 Ω. How much current does the conductor carry when connected to a 2V source? When the conductor is connected to a 4V source. What is the resistance of the conductor?
Exercise 2. Look at the circuit shown in the right side. This circuit consists of a battery, a slide rheostat and a bulb. To measure the voltage across the bulb, we place a voltmeter parallel with the bulb. When the voltmeter measures the voltage between the two ends of the bulb's filament is 6V, the bulb carry a current of 1A. What is the resistance of the bulb? As we shift the slide rheostat to increase the current in the bulb to be 2A, What is the voltage across the bulb?

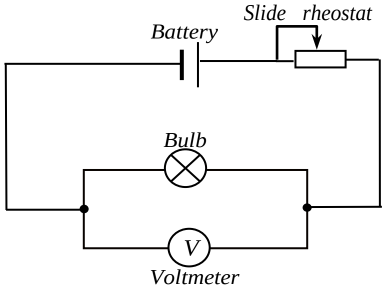

Figure 1. Post-test 1 problems

Table 2. Three Exercises used in the post-test 2

Exercise 1: When a 10Ω resistor is connected in series to a 40Ω resistor, what is the equivalent resistance? When they are connected in parallel to each other, what is the equivalent resistance?
Exercise 2: You are required to assemble a 15Ω resistor, you already have a 10Ω resistor, which resistor does you need and how you connected them? After that you are asked to assemble a 10Ω resistor, you already have a 20Ω resistor, which resistor does you need and how you connected them?
Exercise 3: An 1Ω resistor is connected in parallel to an 100Ω resistor, the total resistance of them is: A. 101Ω B. 99Ω C. more than 1Ω, less than 100Ω D. less than 1Ω

didn't make a reasonable explanation for their choice or gave an explanation. Students whose scores were less than 2 were considered to be unsuccessful and chosen to participate in the first quasi-experimental treatment.

The latter three items in **Table 1**, which distinguished the misconceptions about resistance of category 2, were analyzed by the five-grade marking system. The correct responses to item 3 or item 4 were scored with 1.5; item 5 was 2 points because it is involved with synthesized judgment of cross sectional area and length. This scoring approach was much different from it for items 1 and 2. Student's achievement score of items 1 and 2 was used as a basis merely to distinguish whether or not he/she was successful. However, in the second quasi-experiment, analysis of covariance (ANCOVA) was generated to adjust the effect of instructional treatments on students' conceptual understanding for differences in their conceptual understanding prior to the instructional interventions. Students' pre-test scores of items 3, 4 and 5 were used as the covariate. To highlight the numerical feature of the data we got from the latter three items, the five-grade marking system was employed according to the habit of the junior secondary school's physics teacher.

Post-test 1 was used to evaluate the teaching effectiveness on Ohm's law. Two problems in the post-test 1 were shown in **Figure 1**.

Students were demanded to calculate the value of voltage and current. To achieve these calculations they had to use the unchanging electrical resistance in the formula. Some students were puzzled by the formula as it says that the resistance is proportional to voltage and inversely proportional to current. Whenever they changed the resistance, they were identified to be unsuccessful after the teaching of Ohm's law. Therefore, the data we got from the post-test 1 were also classified into two categories, then the chi-square test statistic was calculated to show whether there was significant difference among different teaching methods. The chi-square test method was used to emphasize particularly on the perfect effect on students' conceptual understanding of Ohm's law. As previously mentioned, even the students who solved one of the two exercises right were identified to be unsuccessful as they didn't had the firm belief that the resistance of the conductor is constant. As Ohm's law is one of the most important concepts in Chinese junior secondary school physics curriculum, it is reasonable to take the teaching effect undergo this rigorous test. But the data used in the chi-square test are nominal variable, thus lose some information which were inherent in the paper and pencil tests.

Post-test 2 was used to examine the teaching effectiveness of "the equivalent resistance of the circuit", which requires 5 times calculations and twice judgments. Post-test 2 was shown in **Table 2**.

Student's post-test 2 marked on a scale from 0 to 10. This scoring method recorded student's varying degrees of conceptual understanding of equivalent resistance after the instructional intervention. Though the chi-square test was the most suitable method to test the teaching effect of Ohm's law, we used different inferential statistics method in the second quasi-experiment. It rooted in the following two reasons. Firstly, compare to the chi-square test, ANCOVA preserved the data information to a maximum extent. Student's pre-test score is a "covariate". Analysis of covariance allows us to adjust the treatment effect to the mean pre-test score of all participants.

Secondly, if the different inferential statistics methods came to the same conclusion, we had more confidence to say that one teaching method was superior to another.

Twenty students in class D of 8th grade (taught by the same physics teacher who instructed classes A, B and C) were selected randomly to participate in a pilot study. They were taught by the traditional method from beginning to end. Above two paper and pencil tests (post-tests 1 and 2) were administered to them before and after the instructional intervention. In the pilot study, student's achievements marked on a scale from 0 to 10, t value were found to be 8.182 for post-test 1, and 7.272 for post-test 2. Because the test is a right-tailed test, $\alpha = 0.001$, and $df = 19$, the critical value is $t_0 = 3.579$. As t is in the rejection region, the results of t test indicate that after teaching intervention, students' scores were significantly higher. Thus the content validity was confirmed. The test-retest reliability of the post-tests was calculated through the Pearson product-moment correlation coefficient method. The reliability coefficients were found to be 0.627 for post-test 1, and 0.862 for post-test 2. The first one seems to be low due to two aspects. On the one hand, to limit the time costs on the post-test, the problems in it were rather few; on the other hand, students were bored to do the same post-test repeatedly and just finished it in a hurry. In the practice of Chinese educational measurement, it is widely accepted that so long as the reliability coefficient of a test compiled by the instructor is no less than 0.60, it is able to be used in the examination (Dai, Zhang, & Chen, 2005; Wang, 2005).

Other Date Sources One purpose of this study is to investigate the common sense held by students on electrical resistance. As far as some students who were not good at written language were considered, the data regarding students' misconceptions were also derived from other sources: audio-recordings, classroom discussions, conversations with teacher after class. These data sources were necessary for capturing the real thoughts of students. Though some students did not write anything to explain the reason for their choices in pre-test's items, their inner beliefs did emerge from the conversations with classmates and teacher.

RESULTS

Students' Misconceptions about Electrical Resistance

In the last month of the first semester of 8th grade, students participated in the learning of chapter 5 "Current and Circuit", though electrical resistance was not discussed in this chapter, students did come into contact with the entity and the symbol of electrical resistance (Peng & Du, 2006a) and a brief statement was made to explain the effect of resistance in the circuit (Peng & Du, 2006a). Some students would rearrange their experiences and get their everyday concept of resistance. However, not all the false responses found in the pre-test were listed in the following tables because some of them are just guesses rather than stable, existing beliefs. Either the false response reappeared in several students' homework, post-tests and conversations with teacher after instructional intervention, or students who made a specific false response were more than 33 (20% of the population) on items 3, 4 or 41 (25% of the population) on items 1, 2 and 5 can it be identified as misconception. Because students may believe the equivalent resistance of a series (parallel) combination of resistors is the sum (subtraction, product or quotient) of the individual resistances or equal to one of the individual resistances, therefore, the probability of the one be chosen are no more than 20%. Meanwhile, there are four choices in the items 1, 2 and 5, the probability of the one be chosen are no more than 25%. The certain option be chosen was just a possibility, but it actually chose by lots of students represented a universality, so it can be an inner misconception. In addition, some entries which listed in the following tables as misconceptions also showed some kinds of logical deduction or mathematical deduction. It was a sign that students have placed this kind of misunderstanding into their existing conceptual framework internally.

This section is devoted to describe students' misconceptions about electrical resistance. This activity is meaningful for conceptual change. When students' real thoughts were known to teacher, the teaching strategies can be developed to not only generate the maximal conceptual conflict, but also achieve the conceptual change. Pseudonyms were used to protect the students' identity.

Misconceptions of Category 1 The following excerpts were taken from students' presentations in pre-test, classroom discussions and communications with teachers and represented students' misconceptions about electrical resistance of category 1.

Amy:	When the electrical resistance decreases, the current is lessened, so the bulb light is dimming.	The electrical resistance is proportional to current
David:	The more current the conductor carries, the more obstacles it meet, the bulb light grows brighter at the same time.	
Lisa:	The resistance decreases with increasing current, so the bulb light grows brighter.	The electrical resistance is inversely proportional to current
Christy:	As the battery's voltage decreases, the bulb's resistance lessens, and the bulb light is getting dimmer.	The electrical resistance is proportional to voltage
Doug:	The resistance is an obstacle to voltage, therefore, the voltage decreases as the resistance increases, the current flowing through the circuit is diminished and the lamplight is growing weaker.	The electrical resistance is inversely proportional to voltage
Brenda:	The slide rheostat is an element which can change other electrical elements' resistance, thus contribute to the illumination of a bulb.	The resistance has relevance to slide rheostat

It was not surprising that students considered the electrical resistance was proportional to voltage and inversely proportional to current. What astonished the researchers was that students believed the electrical resistance was inversely proportional to voltage and proportional to current. Most of them were conscious of their current ideas as they could write it down in the paper. Though student had not studied electrical resistance in the formal teaching context, he/she put forward explanations based on everyday experience and logical reasoning (maybe it is incomprehensible to teacher, it is reasonable to himself/herself). In addition, the great majority of students came to their conclusions with mathematical proportional relations, which showed their ability and willingness to supplement logical reasoning with mathematics.

Misconceptions of Category 2 Students misconceptions about electrical resistance of category 2 are even more complicated and confused. The following excerpts revealed that students employed rational analysis and analogy to get their conclusions.

Paula:	As two resistors connected in parallel, the voltages across the resistors are the same because each is connected directly across the battery terminals, i.e., $V = V_1 = V_2$, the relationship between the equival resistance and the individual resistances is the same as the voltages, i.e., $R_T = R_1 = R_2 = 5\Omega$.	Reasoning and analogy
James:	The current of a series circuit is invariable from one place to another, i.e., $I = I_1 = I_2$, the relationship between the equivalent resistance and the individual resistances is similar to the above relationship, i.e., $R_T = R_1 = R_2 = 5\Omega$	
		Qualitative analysis of item 5
Julie:	As the length and cross sectional area changed simultaneously, the resistance inherent in the wire is constant.	Resistance is dependent on the body
Leigh:	Since the circumference of the wire is unchanged, the resistance is constant.	Resistance is dependent on circumference
Cheryl:	Whatever how many times the wire is elongated, as long as the volume is constant, the resistance will be unchanging.	Resistance is dependent on volume
		Integrated quantitative and qualitative analysis
Jon:	In a parallel circuit, the current breaks into two parts and flowing through 5Ω resistor separately, thus the total resistor is 10Ω.	Vivid imaginations
Willie:	I used to believe that the upper branch was shortened by the nether branch, so the total resistance of the parallel circuit is 5Ω. Now I changed my opinion, as the current was set back twice, the total resistance should be 10Ω.	
Jason:	Unfortunately, both of you are wrong. Since the electrons are not idiot, they just flow through one branch, so the total resistor of parallel circuit is no more than 5Ω.	
Ted:	I believe the total resistance of parallel circuit is 0, as the currents flowing through different branches conflict with each other on the node of the electric circuit, thus lead to the resistance reduced to 0.	
Kevin:	In a series circuit, the current flowing through two resistors is the same, since resistance is the representation of an obstacle which current confronted, so long as the current is unchanging, the total resistance of the series circuit is 5Ω.	Logic thinking

Table 3. Effectiveness of Different Teaching Strategies on Ohm's Law

Teaching strategy	Conceptual understanding		Total
	successful	unsuccessful	
Lecturing format	2	44	46
Inquiry with control variate method	9	41	50
Inquiry with image method	16	34	50
Total	27	119	146

$\chi^2(2, n = 146) = 12.17, p < .01$

Some students operated analogy method to get the relationship between the equivalent resistance and the individual resistances consciously. They wrote down: "In the parallel circuit, the voltage across the total resistance is equal to the voltage across the individual resistance, so the total resistance is equal to the individual resistance." Besides, some students deduced the relationship between resistors from the relationship between currents.

The excerpts in above two tables also show some students' metaconceptual activities. Despite tremendous differences between experts and novice learners had been reported (Glaser & Chi, 1988; Sternberg, 2001), we found that novice learners do manifest their inner awareness of their cognitive structure to a certain extent. They could transfer prior knowledge into a clear expression, support their opinions by logical reasoning. This behavior displayed "one's knowledge and control of one's own cognitive system" which defined as metacognition by Brown (1987). Maybe junior secondary school students are not good at metacognition, but their desire to display the progress in science learning made them execute a conscious metaconceptual activities. Especially their aspirations were ignited by group debate and classroom discussion.

Meanwhile, students' status of mental disequilibrium also immerged in the classroom discussions and conversations with their teacher, students questioned: "A conductor has its resistance while the voltage across the conductor, the current in the conductor. Why the voltage across the conductor and the current it carries can be changed, its resistance can not be changed?" Some of them asked: "You (physics teacher) said that the resistance is an attribute of an object, it is a constant. But why the resistance of the conductor changed according to its length and cross sectional area? You had told us that the mass is also an attribute of an object, and the object's mass would still be constant as its shape changed. It seems that your statements are inconsistent with each other. But you are a teacher. You would not make mistakes, what's wrong with me?"

Even the extracts above are examples of students' misconceptions about resistance, we are aware of the positive aspect of these examples. Students' enthusiasm to share opinions with classmates, their employment of rational analysis and analogy, and their metacognitive activities made the science learning has a massy foundation.

Effectiveness of Different Teaching Strategies on Ohm's Law

To investigate the effect of different instructional strategies on students' conceptual understanding, we selected subjects who displayed misconceptions about resistance of category 1 in Pre-test. This meant that 46 students in class A, 50 students in class B and 50 students in class C were selected.

Class A was comparison group instructed by didactic lecturing supplemented with demonstrations. Class B and class C were experimental group instructed by inquiry methods. Students' conceptual understanding after instruction were identified by post-test 1 and classified into two categories: successful and unsuccessful. See **Table 3**.

Because $\chi^2 = 12.17$ was in the rejection region, there was enough evidence at the 1% level of significance to conclude that the teaching strategy and conceptual understanding were dependent. In other words, the difference of conceptual understanding on Ohm's law among different teaching strategies was statistically significant. Three 2×2 contingency tables were used to make further testing. The results showed that when lecturing format or inquiry with control variate method was applied to students, the difference of conceptual understanding was statistically significant ($\chi^2(1, n = 96) = 4.4, p < .05$). The difference between lecturing format and inquiry with image method was also statistically significant ($\chi^2(1, n = 96) = 13.26, p < .01$). Contrary to what the first quasi-experimental design has expected, the difference among two inquiry teachings using different skills was not statistical significant ($\chi^2(1, n = 100) = 2.26, p > .05$). From these differences above we may conclude that students were more apt to change their misconceptions by inquiry teaching than by lecturing format.

Pines and West (1986) proposed three possible outcomes of instruction when there is a conflict between the academic knowledge and student's belief system, i.e.: conceptual exchange, compartmentalization, and no learning. Compartmentalization is a status where the new knowledge and old belief system coexist. However, according to the synthesized model another possible outcome is "partial change", which means students just modified the "protective belt"(e.g., electrical resistance is inversely proportional to voltage) and preserved the "hard core" (electrical resistance changed according to the voltage across the conductor) of their misconceptions. In this study,

Table 4. Levene's test of equality of error variances[a]

F	df_1	df_2	Sig.
2.519	2	162	.084

Dependent Variable: Post-test
[a] Design: Intercept + Teachingmethod + Pre-test + Teachingmethod * Pre-test

Table 5. Tests of between-subjects effects
Dependent Variable: Post-test

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Teaching method * Pre-test	3.680	2	1.840	.345	.708

46 students (32%) changed resistance in both two exercises, some of them didn't make any progress in conceptual understanding, the others did make some modifications on the "protective belt" of their misconceptions, all of them were classified to be "no learning" and "partial change". 73 students (50%) who use the invariable resistance in one problem and the changed resistance in another problem were classified as compartmentalization (total=146). For these 73 students who had special mistakes checked out from post-test 1. We found that 7 students (9.6%) made a right response to exercise 1 without circuit diagram, and 66 students (90.4%) did a correct calculation to exercise 2 with a circuit diagram. This phenomenon had a significant educational implication on conceptual understanding. When students thinking were assisted by some kinds of diagram, it may be helpful to inhibit his intuitive knowledge and release the scientific concept.

Effectiveness of Different Teaching Strategies on Equivalent Resistance

In the learning of Ohm's law, students who used control variate method got the formula: $I = \frac{V}{R}$, then they deformed it to be: $R = \frac{V}{I}$ (students who used image method get this formula directly). Resistance is defined as the ratio of the voltage across the conductor to the current it carries. For many ohmic materials, the resistance remains constant over a wide range of applied voltages or currents. To obtain multifaceted comprehension of resistance, students should engage in additional studies on "the equivalent resistance of the circuit". So the Ohm's law and equivalent resistance are combined to the same section or contiguous sections in Chinese physics textbook (Peng & Du, 2006b; Yan & Wang, 2006).

In this study, the second quasi-experiment was designed to investigate the effectiveness of different teaching strategies regarding the equivalent resistance. The purpose of this quasi-experiment mainly focused on the re-examining the effectiveness of inquiry teaching. It has been mentioned that class A was instructed by inquiry method (IM), and class B, C were instructed either by language description (LD) or logic reasoning and mathematical deduction (LRMD). From the first quasi-experiment, we had concluded that the difference of conceptual understanding regarding Ohm's law between inquiry method and didactic lecturing format was statistically significant. Does inquiry teaching always do better than lecturing format? If it is true, the results must be repeated. Students' post-test 2 scores were analyzed by using ANCOVA to adjust the effect of instructional treatment on students' conceptual understanding for differences in students' conceptual understanding prior to the instructional interventions. The results were analyzed by using SPSS statistical software and the Levene's test of equality of error variances can be seen in **Table 4**. So the error variance of the dependent variable is equal across groups. Tests of between-subjects effects can be seen in **Table 5**.

Since the significance value was 0.708, there was no interaction between covariate and fixed factor. Therefore, the two primary conditions of ANCOVA were met. The results of the ANCOVA generated to compare group's mean scores on post-test 2 were presented in **Table 6**. Meanwhile, the univariate tests resulted in significant *F* values ($F=6.475$, $p<.05$), which consisted with the pairwise comparisons. These results indicated that there was a significant mean difference among groups when the significant difference in students' pre-scores was statistically controlled. Students instructed by didactic lecturing format with LRMD strategy were more successful in conceptual change regarding equivalent resistance. From this finding, the inquiry method did better in students' conceptual change regarding Ohm's law, which had not been repeated. Thus we might conclude that inquiry teaching would not always be the best strategy in conceptual change. After an in-depth study on the inquiry teaching, we find the difference between this inquiry and previous inquiry. In previous inquiry, most students got the conclusion after the inquiry experiment and group debate. When it comes to the inquiry experiment of equivalent resistance, though they did find that the total resistance of the parallel circuit decreased, as the relationship between the equivalent resistance and the individual resistances is nonlinear, they just could not get the formula by themselves. The conclusion was told by the teacher, so students' metaconceptual processes didn't have a beginning and an end, especially the solution of their largest cognitive conflict between existing beliefs (the simple relationship between the equivalent resistance and the individual resistances) and scientific conceptions (the

Table 6. Pairwise Comparisons
Dependent Variable: Post-test

(I) Teaching method	(J) Teaching method	Mean Difference (I-J)	Std. Error	Sig.
LD	IM	.075	.441	.866
	LRMD	-1.337*	.441	.003
IM	LRMD	-1.411*	.441	.002

Based on estimated marginal means
* The mean difference is significant at the .05 level.

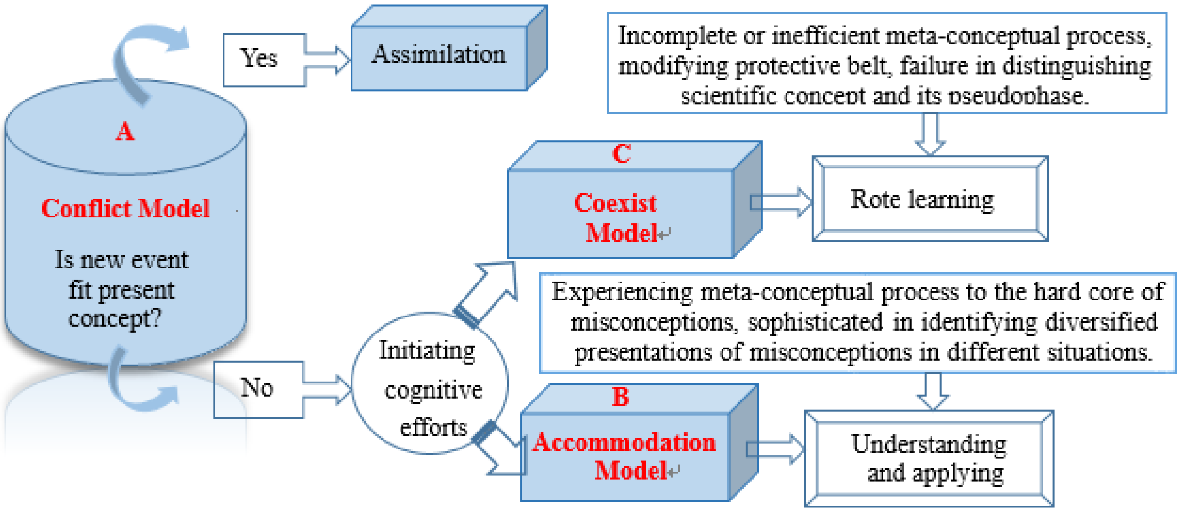

Figure 2. Synthesized students' conceptual change framework: Three models

nonlinear relationship between the equivalent resistance and the individual resistances) was not achieved by themselves. The same thing happened in the language descriptive teaching. In the logic reasoning teaching, though there were not so much extinct metaconceptual processes, some students comprehended their teacher's mathematical deduction and deduced the formula later respectively, thus achieved conceptual change.

DISCUSSION

By integrating the meta-cognition to explain students' conceptual change and our finding result, we develop a synthesized theoretical framework as shown in the Figure 2. The conflict model is developed based on CCM theory, students are not satisfied with the new events contrary to their existing belief system, and arising learning requirements. Generally, meta-conceptual process in coexist model is inadequate, students could not find all the mistakes inherent in their original concept, and failure in affirming the consistency between their original concept and the scientific concept. Which students experiencing adequate meta-conceptual process is accommodation model, they confirming all errors in their original concept and understanding the scientific concept (meta-conceptual awareness), familiar with the acquisition/deducing process of the scientific concept, knowing exact location where the original concept been proved false (meta-conceptual monitoring), identifying and applying the scientific concept to solve problems in all kinds of situations (meta-conceptual evaluation).

What we pay more attention to is the Conceptual Change Model (CCM). The CCM is viewed mainly as a process dimension of conceptual understanding (Posner et al., 1982). To make a successful science education, it is vital to achieve conceptual framework shift. Though the CCM, cognitive conflict, metacognition all contain some kinds of practical activities, we think that the methods or strategies in CCM are different from their counterparts in cognitive conflict and metacognition. We distinguished teaching methods or strategies into two categories. The first refers to hands-on, minds-on activities and questioning, concept mapping and classroom discussion, which can lead to metacognition or conceptual conflict. This kind of teaching methods roots in cognitive and educational psychology. The second refers to control variate method, image method, analogy, mathematical deduction and so on. They are teaching methods as well as research approaches employed by physicist. This kind of methods derived from physics and mainly discussed in physics and philosophy of science. What the procedures drawn from educational psychology and from physics have in common is that they are some kinds of communication and interaction between students and their teacher. As far as the individual's metacognition is concerned, it also contains some kinds of dialogue and communication with his/her existing conceptual structure. However, the procedures drawn

Table 7. Students' conceptual framework shift of electrical resistance of category 1

Processes	Students' understanding of electrical resistance of category 1
Typical misconceptions	The more/less current the conductor carries, the more/less obstacles it meets As the battery's voltage decreases, the bulb's resistance decrease/increase
Metaconceptual knowledge and awareness	The lightbulb brightness is influenced by its current The lightbulb brightness is influenced by its voltage
Metaconceptual monitoring	Students retrieve what they had done in the inquiry classroom and have a clear vision: unchanging the conductor in the circuit, its current grows in pace with the voltage; replacing the conductor and keep the voltage unchanging, the current in resistor is inversely proportional to its resistance.
Metaconceptual evaluation	Students got the formula $R = \frac{V}{I}$ and defined resistance as the ratio of the voltage across the conductor to the current it carries. Therefore, they came to the hard core of their misconceptions that resistance can be changed, and finally realized that resistance is a fixed constant of variation

Table 8. Students' conceptual framework shift of electrical resistance of category 2*

Processes	Students' understanding of electrical resistance of category 2	
Typical misconceptions	In the parallel circuit, as far as $V = V_1 = V_2, R_T = R_1 = R_2$ In the series circuit, as far as $I = I_1 = I_2$, $R_T = R_1 = R_2$ In the parallel circuit, the total resistance is equal to the sum of individual resistance where current flows through, i.e. $R_T = R_1 + R_2$	
Metaconceptual knowledge and awareness	The voltage drops across the resistors in the parallel resistance circuit must be equal In the series circuit, all the current that flows through one resistor must also flow through the other Resistance is a fixed constant of variation Mathematics has much better efficiency than vivid imaginations	
Metaconceptual evaluation	Parallel circuit: $V = V_1 = V_2$ $IR_T = I_1R_1 = I_2R_2$ $\because I \neq I_1; I \neq I_2$	Series circuit: $I = I_1 = I_2$ $\frac{V}{R_T} = \frac{V_1}{R_1} = \frac{V_2}{R_2}$ $\because V \neq V_1; V \neq V_2$
	$\therefore R_T = R_1 = R_2$ would not stand. Students experiencing logic reasoning and mathematical deduction, evaluating their former opinion and find the errors. However, rely on this process can not eliminate mental disequilibrium, further efforts need be done to find the reasonable explanations.	
Metaconceptual monitoring	Parallel circuit: $I = I_1 + I_2$ $\frac{V}{R_T} = \frac{V_1}{R_1} + \frac{V_2}{R_2}$ $\quad \Theta V = V_1 = V_2$ $\therefore \frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2}$	Series circuit: $V = V_1 + V_2$ $IR_T = I_1R_1 + I_2R_2$ $\Theta\ I = I_1 = I_2$ $\therefore R_T = R_1 + R_2$
	Student's thinking process was guided by mathematical deduction, shifting his conceptual framework from the equality relationship (hard core of their misconceptions) to the reciprocal relationship (parallel) or sum relationship (series) As mathematics has much better efficiency than vivid imaginations, students abandoned the sum relationship (parallel circuit, hard core of their misconceptions) and shifted to the reciprocal relationship	

*Taking LRMD method as an example

from physics emphasize its instrumental value, i.e., the scientific methods derived from physics act as a bridge to make the dialogue among contradictory things feasible.

We sorted out and analyzed students' conceptual framework shift based on the mental process with their metaconceptual processes and knowledge categories, as shown in **Table 7** and **Table 8**.

CONCLUSION

The findings of this study improve the theoretical framework of conceptual change. The inferential statistic of the second quasi-experiment has shown that traditional teaching approaches can be effective in student's conceptual change. The crux of the matter is not whether it is traditional, but whether it brings mental disequilibrium and metacognitive activities, then achieved conceptual framework shift. Back to the history of physics, we found that every scientific conception has its evolutional history. Since the conception is concrete and diverse from each other, there can not be a teaching method which would do better in all the circumstances. Meanwhile, based on this study and other researches (Georghiades, 2004; Horton et al., 1993; Yuruk et al., 2009), there are some specific teaching methods effectively on the conceptual change of a given concept. As it is shown in this study, the inquiry method is effective in the learning of Ohm's law and didactic lecturing format with LRMD strategy do better in conceptual understanding of the equivalent resistance.

There are some conceptual frameworks in research of students' conceptions, e.g., the conceptual change model (Posner et al. 1982; Strike & Posner, 1992), cognitive conflict (Gomez-Zwiep, 2008; Kang, Scharmann, & Noh, 2004), and metacognition (Georghiades, 2004; White & Gunstone, 1989; Yuruk et al., 2009). None of them can make a satisfied explanation about the results of this study. But from the synthesized framework it can be interpreted elaborately.

In the matter of cognitive conflict, there are some teaching methods effective in igniting students' mental disequilibrium. It is meaningful in concept learning, but relying on these methods merely are not sufficient to accomplish conceptual framework shift. As discrepant events which contrary to their existing beliefs were observed in the experiments, videos or concept mapping, students were confused with contradictory events. Even though they were aware of the inaccuracy of their existing beliefs, most of them could not change to the scientific concept entirely (Wang, Jou, Lv, & Huang, 2018). They either modified the "protective belt" and preserved the "hard core" or let the new knowledge and old belief system coexist. Thus partial change or compartmentalization status was formed.

In the metacognitive activities, students are aware of their existing conceptions, monitoring their comprehension of the new conception, evaluating the relative status of the new conception in relationship to their existing conceptions (Yuruk et al., 2009). Compared to cognitive conflict, students' initiative activities are strengthened, the discrepant events which they faced before were under scrutiny (Merlin, Maisha, & Max, 2016).

Take this research for an example, to achieve conceptual framework shift, it is vital to employ the instruments or strategies derived from physics. On the learning of resistance, the formula $R = \frac{V}{I}$ was presented to students, their old conceptual framework to comprehend it were merely from the mathematics. The mathematics expressed the resistance is proportional to voltage and inversely proportional to current; however, the physics teacher said the resistance is constant. Therefore, students were puzzled with the contradictory events. To achieve conceptual framework shift, the image method act as an instrument to expose the current is proportional to the voltage for ohmic materials (that is exactly what the mathematics expresses), thus the ratio of voltage and current is invariable. As the mediation of image method, neither the mathematics nor the physics teacher tells lies. The contradiction roots in the misunderstanding of the formula, as the mathematics still be effective in the image method, the mental disequilibrium was eliminated. A new conceptual framework come into being that no matter what the voltage and current vary, the resistance is constant. On the learning of equivalent resistance of parallel circuit, students' old conceptual framework was simple linear relationship, for example, $R_T = R_1 = R_2$, with the teaching strategy of mathematical deduction, it change to a new conceptual framework-"the reciprocal relationship", that is $\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2}$.

Though this study elaborates the positive impact of scientific methods and mathematical method on students' conceptual framework shift, it doesn't mean the methods drawn from physics can always be effective alone. In students' inquiry learning of Ohm's law, the mental disequilibrium and metacognitive activities also contributed to their conceptual change. Meanwhile, the researchers don't confirm the methods drawn from physics, in any event, are superior to metaconceptual processes on students' conceptual framework shift. It roots in two aspects, firstly, the participants are not selected randomly and assigned to each class, and instead, we had to use the currently available classes. Secondly, the junior secondary school physics teacher is not expert in igniting students' metacognitive activities in their inquiry learning.

The findings of this work enlightened the importance for teachers to pay efforts to probe students' misunderstanding of a certain physics concept and design correspondent teaching method to accomplish conceptual framework shift. The scientific methods and mathematical method provide clear, feasible and effective approaches.

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A Study on the Integration of ICT by EFL Teachers in Libya

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ABSTRACT

Given the high importance of adopting ICT into education for developmental purposes in the recent era, the present study is designed to investigate Libyan EFL teachers' attitudes toward ICT adoption in the field of English Language Teaching (ELT). This study looked into attributes (proposed by Rogers, 1995) contributing to adopting ICT, and, more importantly, addressed the relevance of ICT to the socio-cultural context of Libya and adaptations that need to be made for successful adoption and use of ICT. The participants were selected based on availability. The study had a mixed-method design and both quantitative procedures (surveys) and qualitative procedures (interviews) were used to collect data. Both descriptive and interpretive approaches were utilized to analyze data. The analysis led to the identification of a series of problems which were classified into school-level, teacher-level, student level, and system level.

Keywords: ICT, adapting and adopting, EFL teacher, Libya

INTRODUCTION

The highest rate of literacy in the Arab world belongs to Libya (Rhema & Miliszewska, 2010) which has constantly tried to provide good education for all members of the society regardless of their gender. To keep up with modern advances, some improvements need to be made to the educational system of the country, including the development of Information Communication Technology (ICT) infrastructure which, subsequently, modifies and renews the entire educational process. The adoption of ICT into the educational system, among the other things, includes the development of ICT-oriented curricula and bringing the content to the date. To achieve this goal, first, the obstacles should be identified and removed. The poor condition of the existing infrastructure, unqualified teachers to implement and use of ICT technologies in the classroom, negative attitudes and perceptions about the influence of technology, and lack of access to the internet and technological devices and equipment (Buabeng-Andoh, 2012; Chen, 2008; Hamdy, 2007; Rhema & Miliszewska, 2010) are among factors impeding the implementation of ICT in the current education system in developing countries such as Libya. Of these challenges, adopting ICT by all those involved in education that is, students and teachers are of high importance because they are the ultimate users of technology in the educational environment and their acceptance, reactions and attitudes about ICT considerably affect the success of ICT-enhanced education. The present study is an attempt to study these issues in a state university in Libya. We believe that this study will contribute to the literature because adopting ICT to the Libyan educational system provides developments to the country as a whole. CALL-based English language teaching involves new forms of literacies for both students and teachers. The socio-cultural aspect of ICT affects the acceptance of new technology by people including students and teachers in a given country.

THEORETICAL FRAMEWORK

The term 'ICT' is broadly defined as "forms of technology used for creating, displaying, storing, manipulating, and exchanging information" (Meleisea, 2007, p. 29). Following Collis and Moonen (2001), the application of ICT in education includes a) learning resources (i.e., Educational software, distributed resources via the internet, and video resources); b) instructional organization of learning (i.e., Software and technology tools supporting face-to-face lectures, course management systems like Moodle and Blackboard, and computer-based testing system; and

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Contribution of this paper to the literature

- Adopting ICT to the Libyan educational system provides developments to the country as a whole.
- CALL-based English language teaching involves new forms of literacies for both students and teachers.
- The socio-cultural aspect of ICT affects the acceptance of new technology by people including students and teachers in a given country.

3) communication (i.e., E-mail system, websites offering communication options for the direct sending for e-mail and forms of structured communication, and software system for text-based chat). The definition offered and the subsequent categorization is too general, hence, for the purpose of the current study ICT is used in a more limited definition to include computer and also the most common type of computer-based technologies such as laptops, tablets, smartphones, and software, and internet-based technologies including email, websites, and social networking sites such as YouTube with the aim of English teaching and learning.

Rogers (1995) Innovation Attributes sub-theory which is also used in this study as a framework explains that perceptions of technology adopters are essential to the innovation-decision process. He suggests that to assess the effect of ICT adoption, users' attitude should be evaluated in the early stages of its implementation. Attitudes have been proposed to contain three components: 1) affective or "a person's evaluation of, liking of, or emotional response to some object or person", 2) cognitive or "a person's beliefs about, or factual knowledge of, the object or person", and 3) behavioral or "he person's overt behavior directed toward the object or person" (Gordon, 1969, pp. 24-25). Rogers' postulates that teachers' and students' attitudes and perceptions towards innovation should be examined with respect to five perceived attributes of innovations including 1) advantage, 2) compatibility, 3) complexity, 4) trialability, and 5) observability.

Adoption vs Adaption

Mariam Webster Dictionary (2017) defines 'adopt' as "to take for one's own use (something originated by another)" and 'adaptation' as to "change (something) so as to make it suitable for a new use or situation". Applying the same notions to the context of the present study 'adoption' refers to starting to incorporate technology in educational contexts to get benefits of its potentials in foreign language education. The incorporation of adoption of technology however, requires a further step, that of adaptation, which refers to making the requisite changes in the educational settings (such as, provision of the infrastructure) to pave the way for successful integration of technology.

Factors Affecting the Adoption of ICT

According to Rogers (2003) adoption is a decision that an individual makes concerning the use of an innovation as the best course of action available. There are different factors those affect the adoption and adoption of ICT into teaching and learning. These factors are personal characteristics including educational level and experience, age, gender, educational experience, prior experience of applying ICT tools for educational purposes, overall attitude and perceptions towards ICT tools (Abukhattala, 2016; Drent & Meelissen, 2008; Hismanoglu, 2012; Liaw, Huang & Chen, 2007), computer self-efficacy (Rohatgi, Scherer, & Hatlevik, 2016; Yuen & Ma, 2008), teaching experience (Osei, Larbi, Osei-Boadu, 2014), institutional characteristics including technology accessibility (Usluel, Askar & Bas, 2008), technical support (Korte & Husing, 2007; Yilmaz, 2011), professional development (Hsu, 2016; Mishra & Koehler, 2006), technological characteristics (Albirini, 2006; Martins, Steil & Todesco, 2004), and sociocultural factors (Li, 2002; Liu, 2009).

Teachers' Perception into ICT Adoption in Language Education

A common line of research during the last decades have focused on teachers' and students' attitudes on different aspects of ICT adoption. For instance, Hismanoglu (2012) studied prospective EFL teachers' attitudes about implementation of ICT in the distance higher education system. Majority of the teachers were found to hold negative attitudes to ICT adoption despite having basic computer skills; however, they believed that ICT tools are effective tools for acquiring a good deal of new things (also see Tri & Nguyen, 2014). In the context of Libya, Abukhattala (2016) studied pre-service English language teachers' readiness to integrate technology in some high and secondary schools in Misurata, Libya. The findings indicated that although all the participants were willing to use technology to teach English as a foreign language, they realized some barriers to achieve this goal including lack of funding, scarcity of technological equipment in schools and lack of proper training to use technology.

Another strand of research have concentrated on identifying factors that affect the adoption of ICT in a variety of contexts. Liu (2009) investigated Chinese non-English major students' attitudes toward the adoption of ICT into

English language learning to identify factors affecting the adoption of technology in foreign language education. The findings indicated that the participants had different attitudes about ICT integrating due to factors including ICT attributes, cultural perceptions, computer experience and ICT confidence. In another study, Tri and Nguyen (2012) found that according to the students, the frequency of using ICT was of importance.

Several studies have shown that language teachers have identified several benefits of ICT adoption (Keller, 2000; Zhou, 2003). Generally speaking, the findings of the studies suggest that the more positive are users about ICT adoption, the higher is the probability of attempting to integrate it (Hu, Clark & Ma, 2003).

Moreover, as ICT is developed and implemented in developed countries, its adoption in developing countries like Libya may raise some challenges including resistance against its adoption, because as Rogers (1995) argues cultural/social norms of a country contribute to the acceptance or rejection of a given technology among its people. Despite its significance, very few studies have studied the influence of sociocultural factors. As an example, Li (2002) carried out a about the influence of a local culture related to the use of Internet by students according to Chinese and British students' perceptions. Several cultural differences were found that there were some discriminations between the Chinese and British students in terms of Internet experience, attitudes, usage, and competence.

As the literature review suggests most of the studies investigating teachers' perceptions have been conducted in contexts other than Libya. The available studies have also yielded contradictory results suggesting both positive and negative perceptions about ICT adaptation. It was also observed that only a few studies have addressed the cultural suitability (Thomas, 1987) of ICT. More importantly, the adaptations required to make the context ready for accepting ICT have been the subject of a very few studies. To the best of the author's knowledge, these gaps have not been addressed in the educational context of Libya before. As far as ICT is concerned, some researchers such as Sarfo and Ansong-Gyimah (2010) assert that different perceptions on the part of students, teachers, and education officers can lead to unproductive learning. Thus, the present study is an attempt to investigate these gaps in more depth.

Objectives and Research Questions

The present study is designed to investigate EFL teachers' attitudes toward ICT adoption and adaptation in the field of English Language Teaching (ELT). The study also aims to identify attributes (proposed by Rogers, 1995) contributing to adopting ICT, and also the relevance of ICT to socio-cultural context of Libya and adaptations that need to be made for successful adoption and use of ICT. To be specific, the study seeks answer to the following questions:

1. What are the teachers' overall attitude about ICT adoption in education?
2. What are the major attributes of ICT as identified by the teachers?
3. What are the cultural relevance of ICT tools to norms of Libyan education as identified by the teachers?
4. What are the requirements of ICT to match the socio-cultural context of Libya according to the teachers' view?

METHODOLOGY

The present study was administered in Tripoli University in Tripoli, Libya, Faculty of education, Department of English language. It is the largest university in Libya with a population of over 115,000 students. Although this university was selected through convenience sampling, another important reason underpinning the selection of this university was that it is one of the universities which is equipped with basic ICT infrastructure while most of the other education centers still lack ICT infrastructure because implementation of ICT in Libya is still in its early stages in the context of Libya. Thus, the researcher assumed that teachers who have experienced working with ICT tools can provide more valuable information concerning the benefits and drawbacks of ICT adoption as well as the required adaptations in this setting.

PARTICIPANTS

The participants for this study are 32 teachers in the Faculty of Art and Education in University of Tripoli, the largest state university in Libya. Based on their availability, the teachers were selected through convenience sampling but their participation in the presents study was voluntary. The demographic and educational characteristics of the participants is given below.

Most of the teachers were within 36-above (N = 12, 37.5%) and 31-35 (N = 10, 31.2%) years of age, respectively. One fourth (25%) of the teachers were between 26-30 and only 2 teachers (6.2%) who were almost new teachers were between 22-25 years old. The majority of the teachers (N = 23, 71.8%) had a master's degree and 9 (28.1%) had a PhD degree, all in English Language Teaching.

With regard to the teaching profession, an equal proportion of teachers (31.2%, N= 10), had 1-5, and 11-15 years of teaching experience, respectively, and 37.5% (N = 12) had between 6-11 years of teaching experience. Concerning their approach to teach English, the teachers reported using a variety of teaching methods. All the teachers (100%) reported using 'lecturing' and 93.7% reported 'active discussion' as their most frequently used methods. Twenty-one (65.6%), 16 (50%), and 13 (40.6%) of the teachers reported 'collaborative activities', 'active discussion', and 'demonstration' as the methods used for teaching English by them. 'computer-assisted instruction' was one of the least reported methods reported by only 4 teachers (12.5%). Role-playing was the least reported strategy reported by only 2 teachers (6.2%). Six teachers (18.7%) specified other methods including translations as additional teaching methods they use.

Concerning ICT technology, only 4 teachers (12.2%) had already attended ICT classes with 28 teachers (87.5%) having no training on how to use ICT technologies or other technological tools. Most of the teachers (N = 30, 93.7%) had ICT tools at home while just 2 (6.2%) could get access to the ICT tools at university because they had no such tools at home. No teacher (0%) had to use other sources such as internet cafes in order to access computer. Very few students (N = 5, 3.2%) accessed technological ICT tools from other places like cafes. As far as ICT competency is concerned, half of the teachers (N = 16, 50%) reported having a moderate ICT competence and 14 (43.8%) reported having little ICT competence. Only two teachers (6.2%) reported their ICT competence as high.

INSTRUMENTS

Different instruments were implemented in the current study:

Demographic Information Form

This form is designed to elicit information about characteristics of the participants (age, gender, years of teaching experience, etc.)

Adoption of ICT Questionnaires

This is a questionnaire originally developed by Albirini (2006) to address Syrian EFL teachers' attitudes towards ICT adoption in high schools. The questionnaire has three scales. The first section of the questionnaire (items 1-20) addresses teachers' overall attitudes about ICT. The items are designed to measure the affective domain of computer attitude (items 1–6), cognitive domain (items 7–15), and behavioral domain (items 16-20). The Cronbach's alpha of this section in Albirini's study was (0.90). The second section (18 items) questions teachers' perception into computer attributes (advantage, compatibility, complexity, trialability, and observability). The Cronbach's alpha of this section in Albirini's study was (0.86).The third section of the questionnaire surveys the teachers' perception of the relevance of ICT adoption to the sociocultural context of the society and education. The Cronbach's alpha of this section in Albirini's study was (0.76). All the scales are scored on a 5-point Likert-type scale.

Semi-structured Interview

A group of teachers voluntarily participate in the interview and answer some questions prepared in form of a checklist of open questions.

DESIGN

This study had a descriptive exploratory nature and this approach is suitable when, as asserted by Creswell et al. (2003), little is written on the topic or the people under investigation. In fact, very few studies have addressed the adoption and adoption of ICT in Libyan settings.

This study used a mixed-method design to address the questions under investigation. The importance of mixed-method approaches have been recognized by some scholars (e.g., Brown & Rodgers, 2002; Johnson & Onwuegbuzie, 2004).

PROCEDURE

The present study was conducted during 2016-2017 academic year. In order to implement the study, a letter was prepared by the researcher and signed by the director of the English department as a support letter to the administration of the study and collecting data from the Department of English Language. The acceptance letter was acquired. Then, to establish reliability of the adopted questionnaire from Albirini, the questionnaire was first

Table 1. Descriptive statistics of the teachers' responses in the three domains of the overall attitude scale

Domains	Groups	N	Mean	SD	Std. Error Mean
Affect	Teachers	32	4.11	0.416	0.073
Cognitive	Teacher	32	4.1	0.339	0.059
Behavioral	Teachers	32	4	0.538	0.095

piloted with 30 participants. To this end, the EFL teachers in the department of English language were informed and briefed about the purpose of the study.

In the next step, to implement the real study, a number of 34 teachers' surveys were directed in English classes during a week. Following Dillman's (1978) recommendations, a letter of informed consent, accompanied the questionnaire which itself consisted of the demographic information form of the participants and the three scales. A group of 32 survives have been gathered from the teachers with the acceptance rate of 94.1%.

Thereafter, teachers were recruited for participation in the interview which aimed to elicit information about the perceived adaptations in the current ICT to make it fit the Libyan education system.

DATA ANALYSIS PROCEDURE

The quantitative data collected from the student and teachers questionnaires was analyzed via Statistical Package for Social Sciences (19.0) by performing descriptive statistics while the frequency and percentage of the information in the demographic information form, and Mean (M) and Standard Deviation (SD) of the responses to the questionnaire items and components of each scale were computed.

Qualitative data collected from the audio-recorded interviews administered to some of the participants were transcribed by the researcher and analyzed using an interpretive approach (Lincoln, 1995). To this end, the transcripts were analyzed and several themes were identified by the researcher. However, to ensure validity and to reduce subjectivity, the transcripts were also analyzed by one of the English assistant professors at Tripoli University and areas of mismatch were solved through negotiation so the problems were appropriately placed in school-level, teacher- level and system-level.

RESULTS

Teachers' Overall Attitudes toward ICT

As indicated in the previous sections, teachers completed the Overall Attitude Scale.

Table 1 shows the mean and SD of teachers' responses to the items of the overall attitude scale. **Table 4** highlights that in the affect section, teachers do not afraid of ICT tools (M = 4.2), feel comfortable with ICT tools (M = 4.2), and are satisfied with the presence of ICT tools (M = 4.1). However, in case of the next three items, the teachers reported positive attitudes. The teachers dislike discussions related to ICT technologies with other people tools (M = 3.8), ICT tools appear grateful to them (M = 4.1), and like ICT be used for teaching (M = 4.1).

With regard to the cognition domain, teachers are a little more agreed that ICT tools can enhance students' learning (M= 4.4), are appropriate tools for serviceable and accelerated way for acquiring knowledge (M = 4.2), save time and effort (M = 4.0), and make schools a better place (M = 3.9).

Table 2. Mean and SD of the teachers' responses to the items of the overall attitude scale

	Mean	SD
Affective Domain		
1. ICT tools do not scare me at all	4.2	0.97
2. ICT tools do not make me feel uncomfortable	4.2	0.63
3. I am glad there are more ICT tools these days	4.1	0.75
4. I do not like talking with others about computers	3.8	1.02
5. Using ICT tools is enjoyable	4.1	0.73
6. I dislike using ICT tools in teaching	4.1	0.88
Cognitive Domain		
7. ICT tools are suitable means for saving time and effort	4	0.78
8. Without the presence of ICT tools, learning institutes would be better	3.9	1.05
9. ICT tools should be used with all subject matters	4	0.85
10. To learn about ICT means to waste our time	4.1	0.9
11. ICT tools would motivate students to do more study	3.9	0.94
12. ICT tools are appropriate means of getting information	4.2	0.91
13. I believe that I can teach without ICT tools	4	0.93
14. ICT tools can enhance students' learning	4.4	0.75
15. ICT tools do more harm than good	4	0.92
Behavioral Domain		
16. I prefer to do some tasks by hand and not by ICT tools	3.8	1.01
17. I would buy ICT tools if I had enough money	4	0.87
18. I would avoid ICT tools as much as possible	3.9	0.92
19. I would like to learn more about computers	4	0.84
20. I have no intention to use ICT tools in the near future	4.2	0.92

Table 3. Descriptive statistics of the teachers' results in the attributed of ICT

Attributes	Group	N	Mean	SD	Std. Error Mean
Advantage	Teachers	32	4	0.34	0.06
Compatibility	Teacher	32	4	0.44	0.078
Complexity	Teachers	32	4.1	. 39	0.07
Observability	Teachers	32	4.2	0.36	0.063

In the behavioral domain, teachers agreed that they would avoid ICT tools more than as much as possible (M = 3.9). It is noteworthy that despite minor differences in the mean scores of some items responded by the teachers and students, the differences are not statistically significant suggesting that the teachers and students share almost similar overall attitudes about ICT.

Teachers' Identified Attributes of ICT

The respondent teachers in the current study were surveyed about the four major attributes of ICT.

Table 3 shows the mean and SD of teachers' response to the items of the computer attitude scale to provide a more detailed explanation of the results. In terms of the relative advantage of computers, teachers reported that ICT tools can improve education (M = 4.1) and enhance the quality of students' learning (M =. 4.1), their presence in the classroom makes learning the content very enjoyable (M = 3.5), and they are beneficial for learning language (M = 3.9). However, in terms of item 2, that is, teaching with ICT tools offers real advantages over traditional methods of instruction, teachers (M =. 4.1), probably due to the fact that teachers who are familiar with different teaching methods are in a better position to recognize the merits of technology-based approaches over the traditional teaching approaches.

Regarding the second attribute or compatibility with teaching practices, the responses were as follows: using ICT tools is suitable for providing a favorable way of learning to students (M = 4.0). And, its use proper for many activities those are related to learning languages (M = 4.1).

Fitting of computer use into curriculum goals (M = 4.0) and limited class time for computer use (M = 3.8). In contrast, the teachers did not strongly agreed that ICT tools have a place in schools (M = 3.9).

In terms of complexity attribute, teachers' rate of agreement with items 11 and 12 was a little high. These two items maintained that 'It would be hard for me to learn to use the computer in teaching' (M = 3.9) and having no problem in knowing about the primary operations of ICT tools (M = 4.1). Teachers and shared the idea that ICT tools make my teaching role confused during in-class duties (Item 13, M = 3.9). However, ease of working with ICT

Table 4. Mean and SD of teachers' responses to the items of the computer attribute scale

	Mean	SD
Advantage		
1. ICT tools will improve education	4.1	0.62
2. Teaching with ICT tools offers real advantages over traditional methods of instruction	4.1	0.57
3. Computer technology cannot improve the quality of students' learning	4.1	0.75
4. Using computer technology in the classroom would make the subject matter more interesting	3.5	1
5. ICT tools are not useful for language learning	3.9	0.8
Compatibility		
6. ICT tools do not have a place in schools	3.9	0.89
7. Computer use fits well into my curriculum goals	4	0.78
8. Class time is too limited for computer use	3.8	0.95
9. Computer use suits my students' learning preferences and their level of computer knowledge	4	0.81
10. Computer use is appropriate for many language learning activities	4.1	0.9
Complexity		
11. It would be easy for me to learn to use the computer in teaching	3.9	0.94
12. I have no difficulty in understanding the basic functions of computers	4.1	0.73
13. ICT tools make my teaching activities complicated	3.9	0.73
14. It is possible for everyone to learn to use ICT tools	4.4	0.75
Observability		
15. I have never seen ICT tools at work	4	0.92
16. ICT tools are considered as sufficient teaching tools all over the world	3.9	0.73
17. I have not observed ICT tools used for educational purposes	4.1	0.79
18. I observed some Libyan EFL teachers use ICT tools for teaching	4.7	0.42

Table 5. Descriptive statistics of the teachers' results for the identified sociocultural relevance of ICT

	Group	N	Mean	SD	Std. Error Mean
Cultural relevance	Teachers	32	3.88	0.254	0.045

tools (item 14) was an issue highly agreed by the teachers (M = 4.4) indicating that the teachers probably have higher ICT knowledge.

Lastly, teachers' responses on the observability attribute indicates the same percentage of agreement with items 16 and 17 (M = 3.9). Nevertheless, less teachers more reported seeing ICT tools at work (item 15) (M = 4.0). On the other hand, more teachers reported observing ICT tools at work in the Libyan educational context (4.7). It is of note that this item (18) was the most strongly agreed item of all (M = 4.7).

Teachers' Recognized Sociocultural Relevance of ICT

Teachers were surveyed to find out the relation between ICT and the social and cultural norms of Libya.

The items indicate that knowing how to use ICT is needed by students for their future carriers (M = 4.4), ICT tools are suitable for improving our lives (M = 4.0), the use of ICT tools does not mean that the Arab people will forget about leaning their own traditions (M = 4.0), the ones who are professional at using ICT tools are advantageous over the who are not (M = 4.0), and the wide spread of ICT tools have the advantage of making the life easier (M = 4.0). To a lesser degree but by similar rates, the teachers also agreed with the fact that the ICT tools that are needed should be those which are appropriate for the Arab identity and culture (M = 3.9), and the idea that students like to be taught by human teachers than to be taught by ICT tools (M = 3.5).

To elaborate, the mean scores of the responses were high regarding items 1, 8, 10 and 16. The teachers agreed that ICT tools do not have the ability to make their schools, classes and lives different M = 3.8), 'ICT tools are proliferating too fast' (M= 4.0), using ICT tools make us depend on foreign countries (M = 3.3), and 'ICT tools should be a priority in education' (M = 4.2).

Table 6. Mean and SD of teachers' responses to items of the cultural perception scale

	Mean	SD
1. ICT tools will not make any difference in our classrooms, schools, or lives	3.8	0.98
2. Students need to know how to use ICT tools for their future jobs	4.4	0.66
3. Students prefer learning from teachers to learning from computers	3.5	0.71
4. Knowing about ICT tools earns one the respect of others	3.7	0.98
5. We need ICT tools that suit better to the Arabic culture and identity	3.9	0.71
6. ICT tools can make our lives better	4	0.68
7. ICT use will not prevent Arab people from knowing about their own culture	4	0.78
8. ICT tools are expanding very quickly	4	1
9. Being skillful at ICT means being more privileged over others	4	0.76
10. ICT tools will make us depend more on the foreign countries	3.3	0.73
11. Some social issues should be focused on before the integration of ICT in the educational system	3.7	0.7
12. Our lives are becoming easier because of the rapid development of ICT	4	0.8
13. ICT tools dehumanize society	3.2	0.94
14. Working with ICT tools does not diminish people's relationships with one other	4.3	0.59
15. ICT tools encourage unethical practices	3.5	0.91
16. ICT tools should be a priority in education	4.2	1

Table 7. Teachers' recognized problems with the current ICT in Libya and the required adaptations

Problems	Mentioned by	Description of the problem	Adaptations
School-level			
Poor funding of education	Teachers	With the exception of some major educational centers, Libya's education system is yet unfunded.	- Assigning more budget to the education sector
Inadequate ICT infrastructure	Teachers	Little attempt has been made to build ICT infrastructure so the educational centers can be equipped with ICT facility.	- Developing adequate ICT infrastructure - Providing related hardware and software equipment.
Teacher-level			
Lack of skilled teachers	Teachers	Most institutions in Libya lack computer-literate teachers or ICT experts who can support and manage the internet process.	- Inclusion of ICT courses in teacher training programs - Incorporating mandatory computer training programs for teachers
Resistance towards innovation	Teachers	Some teachers are not willing to change from their traditional pedagogical approaches.	- Assigning incentives to teachers who incorporate technology to their practices
System-level			
Inadequate teaching materials	Teachers	The teaching materials and assignments are not computer-based and do not comply with the current teaching practices.	- New ICT-based materials need to be developed. - Teachers should be allowed to develop their own materials.
Inflexibility of the traditional education system	Teachers	Teachers have to follow the restrictive curricula of the institution in which they work.	- The traditional system should give way to newer teaching approaches which allow ICT-based instruction.

Teachers' agreement with 4, 11, 13, 14, and 15 was high. These items maintain that having ICT knowledge can make the person more respected by others (M = 3.7), some social issues need to be focused on before the integration of ICT in education (M = 3.7), 'ICT tools dehumanize society' (M = 3.2), using ICT tools do not destroy the relationships between people (M = 4.3), and 'ICT tools encourage unethical practices' (M = 3.5).

Teachers' Perceived ICT Adaptations

Following Balanskat et al. (2007), the problems identified by the teachers were categorized in three levels.

At the school level, teachers pointed to the problem of inadequate ICT infrastructure, and to solve this problem they suggested the development of ICT infrastructure and provision of more hardware and software equipment. They also recognized an additional problem, that is, poor funding of education which can be solved by assigning more budget to education at schools. At the teacher-level, the problems are related to lack of computer skill and resistance to computer, and the solutions include inclusion of ICT courses in the curriculum and provision of computer literate teachers.

At the system-level, one of the problems recognized teachers is related to inadequate teaching materials. Moreover, teachers believed that they should be allowed to develop their own materials. Another problem mentioned by the teachers was the inflexibility of the traditional education system.

DISCUSSION

Teachers' Overall Attitudes about ICT

The results of teachers' overall attitudes about ICT in one of the major universities in Libya indicated that teachers were positive about its adoption in the educational setting. These findings are consistent with the findings of some other studies (Abukhattala, 2016; Drent & Meelissen, 2008) but in contradiction with some others (Sarfo & Ansong-Gyimah, 2010).

When teachers find the place of ICT promising, and recognize it as a valuable means of promoting teaching and learning, they are more inclined to adopt it and use it if ICT tools are available to them. It is noteworthy that high optimism about the effect of ICT (e.g., Becta, 2008; Hismanoglu, 2012) by teachers increases the possibility of its adoption (Hew & Brush, 2007). Also, Nneji (2014) argues that human has cognitive, affective, and psychomotor (behavioral) domains which are also representative of the dimensions of the overall attitude scale but teachers should know that all these cannot be fully developed through ICT in education.

Teachers' Identified Attributes of ICT

Computer attributes are strong predictors of the adoption of ICT tools for teaching and learning purposes (Albirini, 2006; Martins et al., 2004). The mean scores indicated that the teachers were overall optimistic about the advantage of ICT tools and its contribution to education, quality of learning, and learning different subject matters. Using ICT tools as a medium of instruction and its pedagogical effectiveness has long been debated. The results of many studies suggest that the high performance of students in classes where ICT is incorporated are usually overestimated and the gains are mainly due to the novelty of the instruments, content or methods rather than incorporation of ICT; that is why, in many contexts students still prefer to be taught traditionally by their own teachers rather than through the help of ICT tools probably because teachers are agents which can change lives of the students rather than vehicles to deliver course content. Moreover, presence of teachers, and direct teacher-student relationship has many positive effects on the teaching and learning process such as its effect on students' motivation (Nneji, 2014), thus, teachers cannot be replaced by computers. In terms of, observability, more teachers reported observing ICT tools at work in the Libyan educational context (4.7). Indeed, teachers agreed with the item, yet, they had seen ICT incorporated and used at different places. Observability and advantage were the most important attributes for adopting technology in Martins et al. (2004), and Albirini (2006) studies, respectively.

Regarding the attributes of compatibility and complexity, teachers specifically believed that ICT tools are preferable learning means for students and suitable for their ICT knowledge and they are also suitable for different activities for language learning. The participants also showed their agreement with the fact that they find it not difficult to understand the primary functions of ICT tools, however, learning the use of ICT tools in real teaching practices is not an easy task. The ease of working with ICT tools was an issue highly agreed by the teachers indicating that the teachers probably have high ICT knowledge. These findings are consistent with the results found by other researchers indicating inadequate ICT knowledge of teachers and students in other contexts (Hatlevik Guðmundsdóttir, & Loi, 2015; Mingaine, 2013).

These findings show that successful incorporation and use of computer technologies cannot be limited to understanding the basic functions of computers; rather teachers need to acquire ICT knowledge specific to a particular content domain and functions required for teaching purposes and performing the academic activities. In other words, teachers need to develop ICT competence. Technological Pedagogical Content Knowledge or TPACK is specifically emphasized as a knowledge that 21st century teachers should develop (Hsu, 2016; Thomson & Mishra, 2007). It is of note that adequate ICT knowledge also results in computer self-efficacy or capability to use ICT by teachers (Aesaert & Braak, 2014; Peralta & Costa, 2007; Rohatgi et al., 2016; Yuen & Ma, 2008).

When teachers develop sufficient awareness about the computer attributes, the adoption and application of ICT in education is facilitated (Rogers, 2003).

The Perception of Teachers about the Relevance of ICT to the Sociocultural Norms of the Libyan Society

The results of the teachers' responses to sociocultural relevance of ICT scale was found to be almost similar indicating that cultural factors play an important role concerning the adoption and adoption of ICT in Libya as recognized by the teachers. To provide a more in-depth analysis, teachers' responses are discussed with respect to every single item of the scale. The majority of the teachers overall recognized ICT tools compatible with Libyan society and education system, as well as a vehicle for enhancing living standards and facilitating living in general. They also considered it as a privilege contributing to finding better future jobs. Also, teachers moderately agreed with the need for ICT tools that are suitable for the culture and identity of Arabic societies, and the students' willingness to learn from real teachers over ICT tools. Indeed, there has always been uncertainty about the positive influence of ICT tools on academic improvement as perceived by teachers in this study. This has also been argued and proved by several researchers (Nneji, 2014).

Moreover, despite current arguments concerning the negative contribution of ICT to societal values (Nneji, 2014), teachers in this study believed that using ICT tools will not interrupt the Arabic people from learning about own traditions and working with ICT tools would not decrease the relationships between people, and do not dehumanize society, and it is important to take into consideration some other social norms before the implementation of ICT into the educational system. Teachers were almost neutral about the fact that ICT tools can decrease their independence and foster unethical practices similar to the findings of some other studies (Liu, 2009).

It is argued that the relationship between humans and their environment is not artificial, advent of ICT has caused education to lose its social aspect so that today, "Social disorientation is one of the pseudo aims or counter aims of education in this postmodern era" (Nneji, 2014, p. 91), and even if they are to be incorporated, the system of norms should be clarified (Rogers, 2003). Computer technologies also have the potential to impose some hidden agendas and certain cultural and moral values (Johnson, 2004); that is why even in the presence of teachers' agreement with its adoption, further social issues should be taken into account (Rogers, 2003; Thomas, 1987).

Teachers' Perception of the Required ICT Adaptations

The teachers' perceived problems hindering the adoption of ICT in Libya and the perceived modifications which can be made to facilitate its adoption indicated that such problems were related to all levels.

At the school level, the fact that teachers pointed to inadequate ICT infrastructure and they recognized the poor funding of education which shows that teachers can look at some problems at a more profound level. Moreover, teachers pointed to the underlying reason or lack of budget which is the underlying reason for this deficiency, i.e., poor infrastructure, etc.

It was also found out that poor ICT competence was the teachers' problem (Al-Oteawi, 2002; Hatlevik et al., 2015), and resistance to computer suggesting that the new generations are more open to computer technologies compared to older generation who find acquiring computer skills demanding (Watson, Proctor, Finger, & Lang (2005). Of course, as reported by the teachers, inclusion of ICT courses in the curriculum and provision of computer literate teachers who can help them to do computer-based assignments which also leads to teachers' professional development (Hsu, 2016; Lawless & Pellegrino, 2007), and assigning incentives to teachers who incorporate technology to their practices for the latter problem could solve this problem.

CONCLUSION

Given the widespread use of technology in the 21st century and its increasing application in the education system, schools in developing countries have initiated incorporating ICT tools more recently. Libya as one of these countries launched the incorporation of ICT in some of the Libyan institutes of higher education few years ago. Although ICT in education in Libya still appears to be in its infancy and e-learning in Libya is still struggling with many challenges, the very attempt to incorporate ICT to education has provided a chance implement e-learning for the different educational levels specifically the higher education. Yet, there are important points that should be taken into account as explained below.

The mere provision of ICT structure and ICT tools for schools does not cultivate the belief of the need for its adoption among people who use such tools. Therefore, the study of teachers' attitudes contributes a lot to the implementation of ICT plans since teachers are strongly influenced by new technologies. That is why Sheingold (1991) believes that adopting technology to the educational system is considered a difficult because of human users rather than because of the technology itself.

Another major point to consider is that, this study brought together a comprehensive picture of the factors affecting the adoption and adaptation of ICT in Libya. The factors identified appear to be interrelated thus this process should be viewed holistically. To elaborate, the barriers identified in this study appear to affect one another. For instance, lack of accessibility to ICT tools discourages teachers to use them so they do not develop appropriate ICT knowledge and skills and try to resist against it. Non-inclusion of ICT into teaching practices, consequently, results in fostering students who lack ICT competence and resist against e-learning. In another circumstance, teachers might have sufficient accessibility to ICT tools but lack of ICT-related training programs may prevent them from making the best using ICT for pedagogical purposes. The findings from the study yielded some useful implications for all stakeholders involved in ICT adaptation and adoption in Libya. In this section, recommendations which improves the adoption and adaptation of ICT in education environment are presented.

IMPLICATIONS

Investment for ICT infrastructure and ICT tools: The absence of technology is one of the major barriers in the implementation of ICT. The country addressed in this study is Libya which has started some investments to foster ICT in education. The evidence shows that although some educational settings have ICT infrastructure, they still confront serious barriers concerning availability of hardware, internet access, technical support, etc. So, scarcity of qualified hardware equipment and appropriate software for educational purposes is a main preventer of the development of the educational ICT in the future. For instance, the availability of poorly maintained ICT tools or inappropriate educational software are more troublesome than being useful because they can disrupt even the best planned lessons (Becta, 2006).

It is worth mentioning that, in addition to ICT investment, one of the basic goals of the local ICT policy implemented in Libya since 2005 is investment in human resources without which ICT strategy cannot be implemented. Currently, an acute scarcity of ICT qualified teachers who should incorporate ICT in classrooms and also educate technically qualified students, are felt (Hamdy, 2007) but the country is trying hard to equip all universities with ICT infrastructure and the ICT training programs to foster a generation of technology literate teachers and students.

Implications at the Teacher Level

Increased efficiency in ICT skills: Lack of ICT knowledge was found as one of the major reasons for selection of technology by teachers. In other words, it is usually due to limited ICT skills that teachers resist against the implementation of ICT not because of didactics reason.

Teacher motivation and reward: Motivation is a key factor in integration of ICT by teachers. If teachers receive support and encouragement by the administrators, they feel more motivated and committed (Andersson & Grönlund, 2009). However, for administrators to deal with the issue of ICT implementation, they should have an appropriate knowledge of it which is currently missing in Libyan institutions but they are progressively trying to develop an understanding of the technical, financial, pedagogical, and administrative dimensions of ICTs in education.

Professional development: Teacher training programs should evolve and give way to new concepts of individual and lifelong learning. One of the most critical skills for teachers in this century is the ICT skill which primarily makes them more confident. However, teachers should update their ICT skills as well as their pedagogical knowledge to be successful.

The current training programmes especially in some developing countries like Libya are very rigid and are fed by the Ministry of Education. However, it is suggested that the incorporation of more school-based programs which can be modified according to particular needs of teachers would be more beneficial. In fact, these programs should instruct teachers how to upgrade knowledge and skill. It is also important for these programs to include teacher training for ICT because the training programs of teachers are not suitable for engaging teachers in the use of ICT for preparing their lessons or for teaching in hand materials (Becta, 2004, p. 51) because the training programs only concentrate on the development of ICT skills rather than the pedagogical aspects of ICT (Becta, 2004). According to Kirkwood and Price (2006), there are two ways to modify the current professional development policies and practices. First, professional development activities should take a holistic approach to development include all stakeholders involved including not only teachers but also teacher educators, senior university managers, etc. Second, the focus should be shifted to underlying pedagogical practices and their impact in a specific educational setting.

Implications at the System Level

Traditional system of schooling: Sometimes education systems do not align with ICT and this impedes the effective use of investments in ICT. Developing countries such as Libya which are quite strict in their cultural and religious orientations do not easily give way to more innovative approaches. However, "to improve the teaching and learning processes, meet the changes in the education market, and satisfy the needs of learners and the community, higher education institutions in Libya have no option but to move with the times and adopt e-learning" (Rhema & Miliszewska, 2010, p. 435).

Impacts on teaching methodology: Introduction of ICT into schools occurred during the last decade. Although, adoption of technology is now compulsory in some educational settings in developed countries, its implementation in developing countries such as Libya is still in its early stages. In fact, the effectiveness of ICT is implemented through its quality and quantity tutoring goals. To this end, organizations should support the new educational methods and practices; otherwise, the conventional methods would not change.

Most of the teachers in this study held positive attitudes towards technology so they are ready to adopt it gradually. The findings of this study as well as the other studies reviewed show that only basement for deep improvements in methodology have been laid and teachers have not yet fully accepted new ICT-based pedagogical practices. (Underwood, 2006).

Curriculum and material development: ICT is integrated into the curriculum progressively. Most the developed countries' teachers already prepare their materials by ICT so the many benefits of ICT has already been proved. ICT can in fact save time by enabling teachers through more cooperation and sharing teaching plans with other teachers with makes preparing lessons easier and faster (Becta, 2006, p. 37).

Sociocultural Considerations

Traditions, social, and cultural values are major constructs in the structure of every society. These values also play a significant in education system of every country. It is argued that "National and cultural identities play an important role in interaction with computer-based learning materials" (Huwail, Sharhan, & Hunayyan, 2007, p. 4). Some scholars such as Dunbar (1991) believe that technology is encoded with the features of the societies which developed it. For instance, software developed in the United States, promote hidden individualistic values which are in contradiction with Islamic values. Therefore, sociocultural and religious values are sensitive issues to be considered by material developers who adapt e-learning. Thus, localization of materials adopted for teaching and learning in ICT-enhanced education systems is of high importance.

Another important point to consider is that Libyan families are still traditional and highly follow their cultural and religious values, they cannot follow most technological advances, and are not aware of the potentials of e-learning. Besides, the level of English is still and this makes the use of technology limited to those who understand English well. Thus, language as another barrier to the implementation of ICT in Libya should be considered (Rhema & Miliszewska, 2010). The above arguments imply that ICT should be adopted and implemented into education with serious precautions so as not to overthrow the ultimate aims of education.

Directions for Future Research

The current findings suggest that teachers have already passed the Persuasion stage of Roger's innovation theory and now have decided to incorporate it but it is not yet clear if they use ICT to improve their teaching. So, conducting more research to identify for what purposes teachers use ICT requires more investigation.

Moreover, since the topics addressed in this study are understudied in the context of Libya, future studies can address factors related to variations in access to technology, teaching and learning approaches, cultural expectations, and the required adaptations, to name a few.

Above all, to achieve generalizable findings that can be applied across the country, the quantitative and qualitative data found through such case studies would not suffice, and administering large-scale national studies would be needed.

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What Factors of the Applicants are Influencing the Performance of Research Science Education? A Back-chaining Evaluation Based on the Data of China National Science Foundation

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ABSTRACT

How to predict the performance of an applicant is a core issue in the process of research project funding. Unlike the traditional way, we use a back-chaining evaluation method to test what factors of an applicant are influencing the performance of the research project based on the data of Chinese National Science Foundation. We find that the gender never affects the performance, and the age group of 41-45 is significantly helpful in improving the performance, but the age group of 46-50 obviously does harm in improving the performance. What's more, the affiliation of 211-poject university could do good to the performance, while the educational or academic titles of academician and Yangtze River Scholar prevent the applicants from improving their performances. According to these findings, we advice to take the measures of implementing some specific research projects, some special projects, and some exclusive projects to varied research groups to improve the research performance.

Keywords: research performance, back-chaining performance evaluation, applicant, influencing factors

INTRODUCTION

Since the 1990s, scientific research and development funds in China have continued to grow at an average annual rate of more than 10%. By 2010, the total expenditure on scientific research has put China the third of the world, with the per-capita spending on researchers amounting to 277,000 yuan (Chinese State Statistical Bureau, Chinese Ministry of Science and Technology, & Chinese Ministry of Finance, 2010). In 2012, Xu, the director of intelligence research room in Ministry of Science and Technology (MOST), predicted that China's research input would be equivalent to that of the United States by 2015 (Xu, 2012).

With the growing investments, scientific research in China has made great achievements: C919 air bus, world's fastest supercomputer Tianhe-I, and the world's fastest high-speed train all have witnessed the great-leap-forward development of Chinese scientific researches that benefit from the increasing funding. However, besides the great achievements, the research funding has also posed some problems, among which the one arouses the most interests and public criticism is the consumption of huge state funding without high scientific performances. China, as it were, has just got out of the shortage of funding, but fallen into a dilemma in terms of defrauding, embezzling and wasting. In addition, research community's primary concern is the "black whistles" in the public research funding. More scholars begin to condemn the unequal starting line. In 2010, Shi and Rao (2010) criticized the problems presented by Chinese review and funding for scientific research projects, deeming it as a waste of resources that erodes the morale, hinders the innovation and limits the scientific potential. That is to say, removing "black whistles" away from research project approval has become the focus in current society. Wan, Minister of MOST, even believed that the critics received were too mild. He also pointed that he felt raged and startled about these issues (Wan, 2013). But even though these problems have been criticized all the time, the relevant statements still rest on subjective judgments, since people have not realized these are caused by lack of effective performance pre-

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Contribution of this paper to the literature

- In terms of posts, more funds should be allocated to institute directors, but not to the deputy directors. If aiming to boost overall output of scientific research, support for research group of secretary should be diminished; while, if targeting to enhancing high levels of output, funds for the group of vice-president should be reduced. Statistics show that the group of director is not only helpful to promote overall output, but also high levels of output.
- If China wants to boost overall output, number of projects undertook by one applicant in a certain period should be reduced to one, or the policy that one applicant can only be funded once in a particular time can be implemented.

evaluation. In other words, whoever the project competent agency or the evaluation expert relied on, both cannot judge what applicants can bring high performance of scientific research, or what characteristics owned by the applicants determine the performance. In this context, the authority agencies and the evaluation experts use titles of post to predict the research performance, because they believe that the achievements in the past must be fulfilled by high performance. Though, Minister Wan (2013) stated that all the evaluation processes should be recorded and trace management should be implemented, he still reached this conclusion rashly. To avoid critics towards research programs and increase research efficiency, we need to form a better understanding of factors affecting performance, and entrust the projects to those who own the features that contribute to high yields. To do this, we should consult the empirical findings drawn on by the applicants to promote achievement effects. To address the issues, according to the international research performance evaluation standards, we decide to use the formed scientific outputs (papers) as the set performance standards, and adopt the reverse evaluation method to judge what factors of applicants affecting outputs efficiency through statistical test. It can help us to find the right trustee to receive public research project funds in China.

LITERATURE REVIEW

Judged by the papers in the database of CNKI (China national knowledge infrastructure) and WOS (Web of Science), the studies on how to select research project applicants (project approval) who might have the competencies to yield well in the future researches focus primarily on analyzing the factors causing low efficiency, exploring the factors determining the projects approval, and studying the fairness in project application.

Wang (1983) finds that the applicant's laziness, cheating, misconducts are sure to lead to low efficiency. Shen (2010) suggests that the relations and human sympathies always influence the research project approvals. Liu, Zhu, and Wang (2005) find those applicants who own administrative rights could get the funding easily by the "right exchanges". Liu (2004), Deng, Guo, and Zhang (2009), and Zhou (2006) have probed into the applying procedure. They jump to the conclusion that the applicants doubt the fairness of the procedure, and the applicants even think they are fighting a "never-win" war against the unfairness. Reinhart (2009) has made an empirical study to find the peer reviews of grant applications in biology and medicine are not satisfactory, and some reforms may be done to overcome the shortcomings. Bornmann and Daniel (2005) examine how the committee peer review could guarantee the reliability, fairness and predictive validity in research project funding procedure. The statistic results show that the committee peer review could play an efficient role in guaranteeing the reliability, fairness and predictive validity. Langfeldt (2001) investigates what factors are influencing the decision-making in the process of grant peer review. His study results show that the determinants of peer review may therefore be accidental, in the sense that who reviews what research and how reviews are organized may determine outcomes. Unlike Langfeldt's frustrating finding, Demicheli and Di Pietrantonj (2007), Henderson and Taylor (2009) find that the peer review could help the authority agencies to find the suitable applicants fairly and surely.

In general, the current researches attach great importance to the study on the approval process of project funding, fairness and effectiveness, because the funds belong to public budget that needs to realize public interests and implement justice and openness. In other words, research projects funded by governments need to undertake the public accountability, accept the public supervision and achieve satisfactory performance, to ensure the maximum scientific outputs within the minimum investments. The academic circles concern how to ensure output efficiency of public investments and how to fulfill fairness and justice in the process of funding through high performance. The original intention of all public finances that fund research projects are to seek a range of talents who can bring high performance, and to entrust the public research responsibilities to them. However, no matter what measurements are taken to promote the funding process, critics have always been received. Some think the applicants being chosen are unqualified; and some think too much attention is paid to the status and the age of the applicants. (Shang, Ye, & Zhao, 2012). This poses us an issue tending to be neglected by the current research: according to the performance achieved by the existing funded projects, what factors on earth are conducive to enhancing study performance. This is a back-chaining research approach, a facility for analyzing factors contributing to performance backward according to the current outcome. Just like a full-grown corn in our hands, we decompose it to analyze what factors contributing to its growth in a backward way. This paper plans to use the results of the finished projects of National Science Foundation in China (NSFC) as the objects and adopt the back-chaining method to test what factors are in favor of boosting performance; of course, favorable factors should be chosen in the process of project approval and review, and vice versa, or the process might be misguided.

METHODOLOGY

Due to the wide varieties of research funds granted by public financial and wide range of applications in China, we cannot involve all the funding projects in one research, and cannot cover all the fields of study either. Considering the operability and feasibility, we only select the projects of NSFC which concern macro-management of social science and relate to government performance as the research objects. In theory, the projects aim to reveal the truth of government management, so as to improve government performance. And the target of enhancing performance is to fulfill public funds' accountabilities, which accords with the original intention of public finance that supports research projects. Compared with other projects, it is reasonable that the ones aim at boosting government efficiency should shoulder more responsibilities given by public fund and performance requirements. With these projects as the research units, the rules affecting the relations between performance of projects funded by NSFC and their applicants could be easily detected. NSFC is considered the best foundation in China, so the rules underlying behind it are also applicable to other research projects in China.

Technological Route

Figure 1 shows the technical route of this study. First, we acquire information of all the finished projects with research topic relating to government performance from NFSC's ISIS system (https://isis.nsfc.gov.cn/egrantweb/). According to the information, we confirm the personal details of applicants, like gender, age, post and etc. Second, we classify the applicants into different groups and calculate the outputs (high level and general level) according to their characteristics. Third, we use Kruskal-Wallis method to put the influence from different factors on the two outputs to the non-parameter test, to confirm whether the influence of various factors show any statistical significance. Fourth, in order to judge which group can bring higher performance, a Mann-Whitney U test is undertook to check the conditions of applicants who host one project and those who direct multiple projects. At last, from the applicants' perspective, we confirm the factors that influence projects output of NSFC based on the two test results, and put forward advices on how to enhance the process of selecting projects and the entrusted (applicants). In particular, the forms of achievements are diversified, including papers, treatises, research reports, policy reports and etc. We only choose the published academic papers as the research objects, because: 1) the proportion between journal articles and treatise is about 35:1. Journal articles contribute to over 70% of information for project research. Moreover, a large number of other project research outputs (prototypes of treatise and research reports) are presented in the form of papers. 2) Using papers to present scientific research achievements has become an international practice (Daniel, 1993). 3) From the statistical point, using samples to deduce parameters can also help us to find the general rules and basic information. The chosen paper can be seen as a sample drawn from the statistical population (research output).

After completing the above steps, in ISIS system, we can confirm that the number of projects (2000-2012) with research topic relating to government performance is 268 in all, among which applicants of 189 projects only have host one in such type, and applicants of other 79 projects have run at least two. But both of the two groups contain an array of unfinished projects by the deadline of January 1, 2013. After removing these uncompleted ones, we select 77 projects from each type. And then, we search full-text in databases of SCI, SSCI, EI and CSSCI (Chinese Social Sciences Citation Index) and receive 883 papers concerning these projects, among which the number of output whose applicants have host only one project is 475 and the number of papers whose authors have done multiple projects is 408. To differentiate research quality, in the light of NFSC guidance on final report, we consider the papers published in source journals like SCI, SCI-E, SSCI, and EI, and in the important journals recognized by Management Science Department of NFSC as high level, and consider the others as the general level. These are gained by subtracting the high level ones from the total. It's important to note that there are a large number of general journals not from these databases having also produced an extensive literature that give clear indications of having received project funds. But, given that publishers of these journals do not erect any wall for publishing papers, and some even provide offers by accepting page fee, sponsorship fee and member fee, so, strictly speaking, these papers cannot become academic achievements. Therefore, we do not include them in the research.

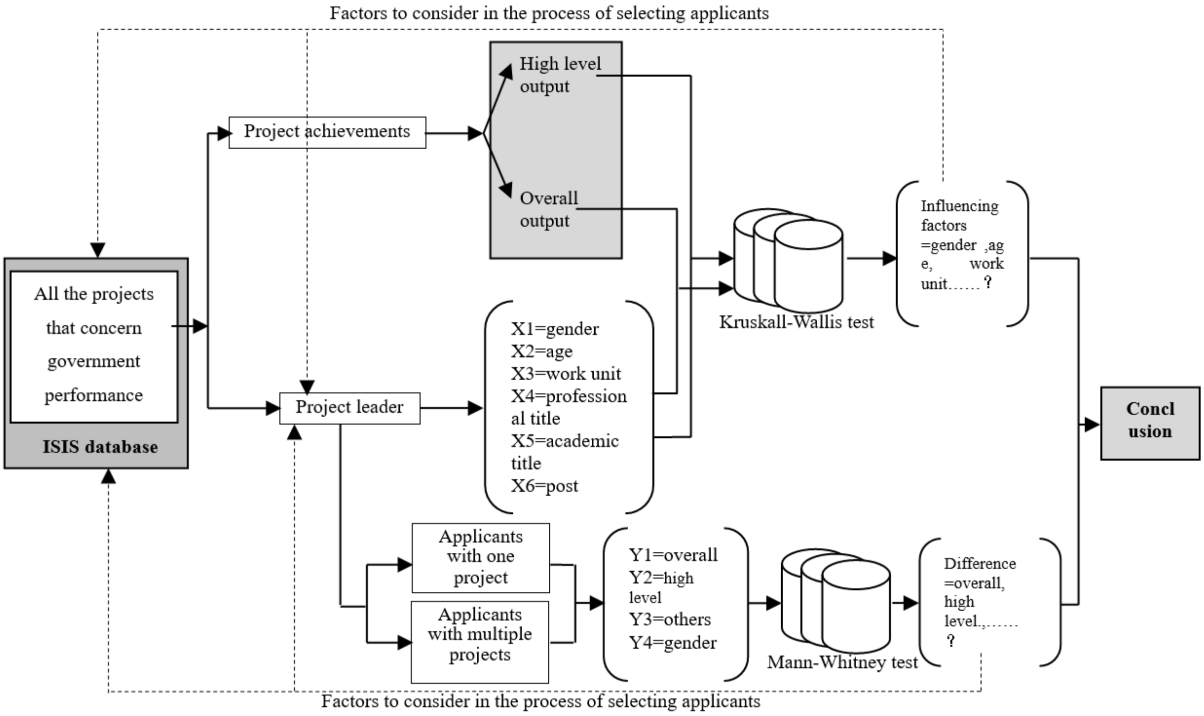

Figure 1. Technical Route

The Factors Influencing Output

As a matter of fact, various features of applicants can affect the output. But from the points of Hartmann (1990), Hartmann and Neidhardt (1990), Daniel (1993), Bornmann and Daniel (2005), the main factors that influence performance are gender, age, post, academic title, professional title and nature of work unit. Later, Reinhart (2009) added that project design ability and implementing capacity were influencing factors either; moreover, they even might be the key ones. This study is also in favor of the above research conclusion, but since only "insiders" are qualified to review the project applications, "outsiders" are hard to gain a better understanding of project design ability underlined by Reinhart. In spite of that, the implementing capacity he put emphasis on can be evaluated via output. The design of influence factors in this paper is also based on the findings, even though we have not planned an exclusive variable quantity. However, as a matter of fact, the back-chaining method used in the paper to test factors via implementing results is consistent with Reinhart's findings.

Gender

Bentley and Adamson (2003), Ceci and Williams (2011), Brouns (2000), Bormann and Daniel (2005) found that discrimination against female existed in the process of project funding, but they also posed an issue in the research that whether female were applicable for doing research or not? Did females tend to bring low efficiency? This study intends to answer these unsolved questions.

Age group

Merton (1973) pointed out that science is a young man's game. So we want to test whether "Merton Rule" exists in social science research, or just like the Chinese traditional saying goes that young adolescents are undependable because they are too young to grow beard. The age groups divided in this paper are based on the age at which the applicants started a project. For applicants who have run multiple projects (Shang & Yu, 2013; Shang, Jin & Liu, 2016), we use person-time method to classify them into the age group that corresponds to the project.

Post

Generally speaking, applicants with some certain administrative post can allocate more human resources, material resources and funds for scientific research, if so, they are in favor of improving research performance. However, in current society, people being both an expert and an official have always been criticized. Many think that the performance must be diminished when experts take an administrative post, so we need to verify which view accords with the reality in our country. We divide posts into vice-principal, president, vice-president, secretary of party committee (no deputy secretary exists in the projects we collected), department head, institute director, institute deputy director and no post. According to the data collected, we find that many applicants hold multiple posts, but we only record the highest one.

Academic title

In a normal, academic titles are always bestowed to the applicants who previously have high research abilities and performances, so such titles are essential to ensure research output. Yet, they have also been criticized, because many people believe that "black whistles" exist in the operation. As a consequence, academic titles cannot represent a researcher's output capacity. In the process of test, the paper divides applicants into groups according to their academic titles, like academician, Yangtze River scholars, talents for Thousand Talents Program, winners of Outstanding Young Investigator Award, finalists of New Century Talents Program, person selected for New Century Talent Supporting Project by Education Ministry, and no title. Among all the titles, we only choose the one filled by the applicant in the first place.

Professional titles

Promotion often comes along with improvement of research capacity, which is significant for maintaining output. However, whether professional titles would affect output or not is still an unsolved question. In the process of test, the study divides post into professor/researcher, associate professor/associate researcher, and lecturer and others.

Nature of work unit

Strictly speaking, work units are unable to bring output. But powerful units tend to benefit more from research funding. Hence, it is necessary to verify whether the powerful units can bring higher output than others. The study divides the work units where applicants belong to into affiliations of 985-project universities, of 211-project universities, general universities, and other institutes, among which "other institutes" include Party schools, administration institutes, and research institutes, etc.

The Statistical Test Method

In terms of traditional practices, researches about determining influence factors are usually done by the multiple regression method. But, as scholars who study statistical theory and statistical software know, if the samples drawn are insufficient, whatever the origins of the statistical software and model are, variables can produce a certain number of regression coefficients. And the coefficients always tend to be statistically significant. This is the spurious regression that hard to avoid in the process of regression (Kao, 1999). The study involves independent tests on various samples and we cannot predict the distribution of population samples. This is consistent with the characteristic of non-parametric test put forward by Kruskal-Wallis that considers normality of the overall probability distribution unnecessary (Chan & Walmsley, 1997). Output of various projects, as well as relations between results and applicants presented in the study may not fully meet formality requirements. However, they right meet the inspection requirements made by Kruskal-Wallis. To verify the relations between projects results and factors of applicants, we ran statistical tests on Mean, SD, Median and Range, according to the test requirements made by Kruskal-Wallis (Shi & Fan, 2007). We would verify the influence exerted by each factor on the overall output and high levels of output in force. The Null hypothesis (H_0) tested in the study is based on the assumption that the influences from each factor on output are same.

Besides the overall verification, another phenomena concerned by society needs to be tested is whether the performance of researchers in charge of various projects is lower than that of the applicants who host just one project, which can also be analyzed via the data we collected. In the case of output, we can see the applicants (in charge of one or multiple projects) as an influence factor, which can also be used to test which group is given the priority in terms of performance. Kruskal-Wallis' test method is not applicable, because we need to test the priorities of the groups. The verification process that unfamiliar with the overall distribution is more suitable to take Mann-Whitney U method. It can be adopted to determine which group is likely to produce more results (Fagerland & Sandvik, 2009). The Null hypothesis (H_0) tested in the study is based on the assumption that performance of applicants in charge of one project or multiple projects are same.

Table 1. Project Output Performance and Applicants' Original Data

Applicant's factors		Number of people (1project/2projects)	Overall output (1project/2projects)	High level of output (1project/2projects)
Gender	male	63/60	394/288	77/72
	female	14/17	81/120	13/29
Age	Under the age of 35	24/14	141/82	34/13
	At the age of 36-40	12/14	64/62	16/14
	At the age of 41-45	16/25	149/100	26/35
	At the age of 46-50	11/7	30/41	5/6
	Above the age of 50	14/17	91/123	9/33
Work Unit	Affiliations of 985 university	40/56	199/297	44/86
	Affiliations of 211 university	11/5	122/34	19/5
	General universities	19/10	114/55	20/5
	Other institutes	7/6	40/22	7/5
Professional Title	professor/researcher	51/59	318/316	46/79
	Deputy professor/deputy researcher	22/17	143/85	36/20
	Lecturer and the others	4/1	14/7	8/2
Academic Title	Academician	1/0	3/0	1/0
	Yangtze River scholar	0/5	0/18	0/5
	Outstanding young investigators	1/1	7/5	0/5
	Thousand talents	0/1	0/6	0/1
	New century program by education ministry	14/17	112/112	23/17
	New century talents	3/1	41/14	11/0
	No	58/52	312/253	55/73
Post	Vice-principal	2/1	9/14	0/0
	Dean	6/10	62/50	9/12
	Associate dean	16/14	79/78	14/20
	College party secretary	0/2	0/8	0/2
	Department head	16/14	122/53	19/11
	Director	6/6	20/60	2/20
	Deputy director	3/1	9/4	0/3
	No	28/29	174/141	46/33

STATISTICAL RESULTS

According to the technical route mentioned above, we finally confirmed the factor data corresponding to applicants' characteristics that influence the output performance. We chose 154 applicants as the research subjects, among whom 77 applicants have just completed one National Natural Science Foundation project, and the other 77 applicants have finished over one project by each. Among these applicants, there are 123 male researchers and 31 female researchers; number of researchers below the age of 35 are 38, above the age of 50 are 31; number of applicants from affiliations of "985-project universities" are 96 and from general universities are 29; there are also one academician, five Yangtze River Scholars, one finalist of the Talents Thousand program, and two winners of Outstanding Young Investigator Award. These applicants produce 883 papers in all (CSSI, SCI, EI and SSCI database achievements), among which 191 ones are of high level. The details are shown in **Table 1**.

Test Result of Relations between Overall Output Performance and Applicants' Factors

In terms of performance evaluation, we consider overall output as the established overall performance, and then test the various factors of applicants by using the back-chaining method to determine which ones actually influence the overall performance. In the statistical test, we sort the factors like gender, age, unit, post, academic title, professional title into the more specific indicators. For specific expressions, separate genders into female and male, and divide age groups into group under age of 35, age of 36-40 and age of 41-45 etc. Based on the original data, we use Kruskal-Wallis test in SPSS20.0 software to verify whether the influence exerted by these indicators on the overall output has statistical significance. The final test results are shown in **Table 2**. As for the overall output, gender does not have any appreciable influence; in terms of the age, three indicators like age of 41-45, age of 46-50 and age above 50 have significant influence (α=0.01); with respect to the work unit, besides affiliations of 211 universities, influence of other factors is not obvious; in regard to the professional title, besides the lecturer and others (α=0.01), influence of other factors is not important; regarding the academic title, influence of factors like academician, Yangtze River scholar and New Century Talents is appreciable (α=0.01), but impact of Outstanding

Table 2. Kruskal-Wallis Test for Scientific Research Overall Output and Applicants' Features

Influencing factors		N	Mean (SD)	Median(Range)	p-value
Gender	male	123	5.54 (6.466)	4.00 (0-53)	p=0.503
	female	31	6.48 (6.821)	4.00 (0-22)	p=0.576
Age	Under the age of 35	38	5.87 (5.179)	5.00 (0-22)	p=0.633
	36-40	26	4.85(4.855)	4.00 (0-19)	p=0.701
	41-45	41	6.07 (8.739)	5.00 (0-53)	p<0.01
	46-50	18	3.94 (4.291)	2.00 (0-14)	p<0.01
	Above the age of 50	31	6.90 (6.935)	5.00 (0-22)	p<0.01
Work unit	985	96	5.17 (5.289)	4.00 (0-22)	p=0.270
	211	16	9.75 (12.725)	6.50 (0-53)	p<0.01
	General universities and other institutes	29	5.83 (5.399)	4.00 (0-20)	p=0.266
		13	4.77 (5.118)	3.0 (0-17)	p=0.194
Professional title	Professor/ Principal Senior	110	5.76 (7.174)	4.00 (0-53)	p=0.522
	Associate professor/ Deputy Senior	39	5.85 (4.76)	5.00 (0-22)	p=0.573
	Lecturer and others	5	4.20 (2.950)	6.00 (1-7)	p<0.1
Academic title	Academician	1	3.00 (-)	3.00 (3-3)	p<0.01
	Yangtze River scholar	5	3.60 (4.827)	2.00 (0-12)	p<0.01
	Outstanding young investigators	2	6.00 (1.414)	6.00 (5-7)	p=0.149
	Thousand talents	1	6.00 (-)	6.00 (6-6)	p=0.149
	New century program by education ministry	31	7.23 (10.042)	5.00 (0-53)	p=0.130
	New century talents	4	13.75 (4.646)	13.00 (9-20)	p<0.001
	No	110	5.14 (5.191)	4.00 (0-22)	p=0.157
Post	Vice-principal	3	7.67 (6.028)	7.00 (2-14)	p=0.892
	Dean	16	7.00 (12.806)	3.50 (0-53)	p=0.877
	Associate dean	30	5.23 (4.904)	4.50 (0-19)	p=0.534
	College party secretary	2	4.00 (5.657)	4.00 (0-8)	p<0.1
	Department head	30	5.83 (6.539)	3.00 (0-19)	p=0.702
	Director	12	6.67 (7.439)	5.00 (0-22)	p<0.01
	Deputy director	4	3.25 (4.272)	2.00 (0-9)	p<0.01
	No	57	5.53 (4.751)	5.00 (0-22)	p=0.666

Youth, Thousand Talents and New Century Excellent Researcher Award Program from Ministry of Education is not remarkable; about the post, apart from the marked impact of party secretary of college (α=0.01), director and deputy director (α=0.01), other indicators are not important.

Test Result of Relations between High Levels of Output and Applicants' Factors

The overall output reveals the general performance in accordance with the rough statistics, while NSFC has always encouraged high levels of achievements. And factors influencing high levels of achievements would not be the same with those affecting the overall output. This is also an issue the research aims to tackle. Here, we also use the high levels of output to test what factors of applicants are affecting the high levels of performance in a back-chaining way. **Table 3** shows the statistical results. It is observed that gender is still an insignificant factor, but the age group of 41-45 has appreciable influence (α=0.1), so does the age group of 46-50 (α=0.01), but other indicators are not important. For work units, apart from affiliations of 985-project universities, the other three indicators (α=0.01) are important; with respect to the professional title, lecturer and the below is a significant indicator (α=0.01), and other factors are not appreciable; concerning academic titles, except New Century Excellent Researcher Award Program from Ministry of Education is not remarkable, the others are significant (α=0.01); regarding post, except indicators of director and deputy director (α=0.01), the others are not remarkable.

Table 3. Kruskal-Wallis Test for High Levels of Output and Applicants' Features

Influencing factors		N	Mean(SD)	Median(Range)	P-value
Gender	male	123	1.21 (2.058)	0 (0-13)	p=0.450
	female	31	1.35 (1.684)	1.00 (0-5)	p=0.471
Age	Under the age of	38	1.24 (1.684)	0.50 (0-6)	p=0.570
	36-40	26	1.15 (1.567)	0 (0-5)	p=0.488
	41-45	41	1.49 (2.051)	1.00 (0-8)	p<0.1
	46-50	18	0.61 (0.979)	0 (0-3)	p<0.01
	Above the age of 50	31	1.35 (2.835)	0 (0-13)	p=0.113
Work unit	985	96	1.35 (2.147)	0.50 (0-13)	p=0.174
	211	16	1.50 (2.033)	1.00 (0-8)	p<0.1
	General universities	29	0.86 (1.529)	0 (0-7)	p<0.1
	Other institutes	13	0.92 (1.553)	0 (0-5)	p<0.1
Professional title	Professor/ Principal Senior	110	1.14 (2.105)	0 (0-13)	p=0.170
	Associate professor/ Deputy Senior	39	1.44 (1.651)	1.00 (0-6)	p=0.133
	Lecturer and others	5	2.00 (1.581)	2.00 (0-4)	p<0.1
Academic title	Academician	1	1.00 (-)	1.00 (1-1)	p<0.1
	Yangtze River scholar	5	1.00 (1.225)	1.00 (0-3)	p<0.1
	Outstanding young investigators	2	2.50 (3.536)	2.50 (0-5)	p<0.1
	Thousand talents	1	1.00 (-)	1.00 (1-1)	p<0.1
	New century program by education ministry	31	1.29 (2.085)	0 (0-8)	p=0.237
	New century talents	4	2.75 (2.986)	2.00 (0-7)	p<0.1
	No	110	1.16 (1.947)	0 (0-13)	p=0.119
Post	Vice-principal	3	0 (0)	0 (0-0)	p<0.001
	Dean	16	1.31 (2.243)	0.50 (0-8)	p=0.484
	Associate dean	30	1.13 (1.925)	0 (0-9)	p=0.399
	College party secretary	2	1.00 (1.414)	1 (0-2)	p=0.381
	Department head	30	1.00 (1.722)	1 (0-6)	p=0.471
	Director	12	1.83 (3.810)	0 (0-13)	p<0.1
	Deputy director	4	0.75 (1.50)	0 (0-3)	p<0.1
	No	57	1.39 (1.645)	1 (0-7)	p=0.198

Table 4. Mann-Whitney U Test for Output Brought by Applicants Who Undertake One Project or Multiple Projects

		N	Mean(SD)	Median(Range)	P-value
Compare the tested projects	Applicant with one project	77	6.17 (7.556)	5.00 (0-53)	p<0.1
	Applicant with multiple projects	77	5.30 (5.319)	4.00 (0-22)	
	Applicant (male)with one project	63	6.25 (7.864)	5.00 (0-53)	p<0.1
	Applicant (male) with multiple projects	60	4.80 (4.513)	4.00 (0-20)	
	Applicant (female)with one project	14	5.79 (6.216)	4.00 (0-19)	p<0.1
	Applicant (female) with multiple projects	17	7.06 (7.420)	4.0 0-22)	

Test Result of Output Performance Difference between Applicants with One Project and Multiple Projects

According to the original data, we use Mann-Whitney U method in SPSS20 to verify the performance difference between applicants who did one project and who ran multiple projects, in terms of total output and production process of high level of output. In the process of verification, we start from testing the difference between the two groups generally, and then test the group difference based on gender. The test results are shown in **Table 4** and **Table 5**. From **Table 4**, it is noticeable that the performance gap between applicants with one project and those with multiple projects is great (α=0.1); the gap among applicants (female) with one project, applicants (female) with multiple projects, applicants (male) with one project and applicants (male) with multiple projects is also remarkable large. In the light of high level of output, performance difference between applicants with one project and those with multiple projects is not obvious; so is the performance difference between applicants (male) with one project and applicants (male) with multiple projects, but the difference between applicants (female) with one project and with multiple projects is remarkable.

Table 5. Mann-Whitney U Test for High Level of Output Brought by Applicants Who Undertake One Project or Multiple Projects

		N	Mean(SD)	Median(Range)	P-value
Compare the tested projects	Applicant with one project	77	1.17 (1.831)	0 (0-8)	p=0.504
	Applicant with multiple projects	77	1.31 (2.135)	1 (0-13)	
	Applicant (male)with one project	63	1.22 (1.913)	0 (0-8)	p=0.912
	Applicant (male) with multiple projects	60	1.20 (2.216)	0.50 (0-13)	
	Applicant (female)with one project	14	0.93 (1.439)	0 (0-4)	p<0.1
	Applicant (female) with multiple projects	17	1.71 (1.829)	1 (0-5)	

Table 6. Factors of Applicants Influencing Output

Influence factor	Overall output performance	High level of output performance
age	41-45 (6.07) ↑ 46-50 (3.94) ↓ Above 50 (6.90) ↑	41-45 (1.49) ↑ 46-50 (0.61) ↓
work unit	211 (9.57) ↑	211 (1.50) ↑ general universities and the others (0.92) ↓
Job title	Lecturer and others (4.20) ↓	Lecturer and the others (2.00) ↑
academic title	Academician (3.00) ↓ Yangtze River scholar (3.60) ↓ New century talents (13.75) ↑	Academician (1.00) ↓ Yangtze River scholar (1.00) ↓ Outstanding young investigator (2.50) ↑ Thousand talents (1.00) ↓ New century talents (2.75) ↑
Post	College party secretary (4.00) ↓ Director (6.67) ↑ Deputy director (3.25) ↓	Vice-principal (0) ↓ director (1.83) ↑ deputy director (0.75) ↓

CONCLUSION

To present the research findings directly, we can simplify the statistical results. On the basis of the previous results, **Table 6** reveals what factors of applicants are influencing output performance. What within parenthesis are mean values of influence factors, among which "↑" means the one tends to cause high performance, and "↓" indicates the one contributing to low performance.

First, in terms of age, applicants between the age of 41 and 45 are helpful to promote overall output or high level of output, however, applicants within the age of 46-50 are obviously adverse to the two outputs, but applicants above the age of 50 are in favor of the overall scientific output. From **Table 6**, we can find that applicants within the age of 41-45 are able to achieve high performance, both in high output and overall output. Their mean values are remarkably higher than those of applicants in other sections. This maybe because applicants in this age group are still young and energetic, they are striving to fulfill academic achievements, gain academic titles and professional titles. However, applicants between the age of 46 and 50 are in a low-performance section. On the basis of the statistical results, this age group is obviously adverse to overall output and high level of output, due to that applicants in this group have attained their academic status, so promotion pressure is not as high as that on other groups. It is interesting that the age group above 50 is significant to the non-high-level output. The overall output brought by the group is remarkably higher than that of other groups. Due to the better academic accumulation and greater social influence, more attention is paid to the academic output of this group; journals and magazines tend to invite them to write papers regularly.

Second, on the basis of work unit where applicants belong to, affiliations of 211-project universities have a positive impact on promoting overall output and high level of output, but the general universities and other institutes are adverse to high level performance. Based on the statistical data, affiliations of 211-project universities are capable to increase the overall output and high level of output significantly, which is different from the traditional idea that affiliations of 985-project universities are more likely to bring higher performance. Those affiliations of 211-project universities tend to implement the research funds supporting system and research achievements reward system, while affiliations of 985-project universities are likely to believe that running research projects and promoting output are the responsibilities of researchers. From **Table 6**, general universities and the others are adverse to high level of output due to lack of qualified faculties. So they are more likely to bring general-level achievements.

Third, from the point of post, though the group of lecturer and the others is conducive to high level of output, they are adverse to increase in overall output. Compared with other applicants, lecturers and the others tend to produce high level of output, not the overall output. This suggests that the group is adverse to the increase in overall output, especially the general level of output. This is because those young researchers are the majority in the group. Though most of them have received rigorous academic training, they have not formed academic and social influence. Good training contributes to high level of achievements, but lack of influence reduces the opportunities for advanced arrangements for their contributions and special manuscripts, which decreases the output in turn.

Fourth, from the point of academic post, rather than in favor of research performance, titles like academicians and Yangtze River scholars are adverse to overall and high level of performance. But talents from New Century Talents Project are conducive to the two achievement effects; and outstanding youths can promote high level output performance, but title like Thousand Talents goes against high performance. Though, in reality, work units are striving to recruit academicians and Yangtze River scholars, applicants with the two titles tend to bring low performance. This is because that these scholars have accomplished both success and fame, they are short of study motivation. In the field of social science, due to their older age, researchers with the two titles have already missed their golden research cycles (Horner, Rushton, & Vernon, 1986). While talents in New Century Talents Project and gainers of NFSC Basic Youth Foundation tend to be younger than members of the former two groups. They are still concentrated on scientific research, which is the main factor stimulating them to promote the overall and high level of output. It is unexpected that talents of Thousand Talents program cannot improve performance. Since the program intended to bring in a batch of researchers worldwide of international level, they are supposed to be adept at gaining high level of achievements. Due to the long cycle of scientific study, they are still in the process of undertaking projects to bring high level of output after they returned.

Fifth, from the point of post, director is conducive to overall output and high level of output, but the deputy director is the opposite; party secretary is in favor of improving the overall output, but the vice president is the opposite. In statistical terms, directors of various research institutions are creators of significant performance. Their overall output and high level of output are remarkably higher than those of other applicants, but the deputy directors are the opposite. This is because the directors are generally more experienced professionals and technical talents. And deputy directors might still need to hone their professional skills. Technically speaking, party secretary and vice-president belong to administrative personnel, who are in charge of recruitment and mastering ideology of students. Hence, they are hard to spare more time to pursue scientific research, which affects the promotion of overall output and high level of output.

Sixth, considering the number of projects, compared with applicants undertaking multiple projects, applicants with one are more conducive to improving overall performance. As shown in **Table 4**, both the overall and high level output of applicants with one project is higher than those of applicants with multiple projects from either the general or the gender perspective, which explains the existence of diminishing utility in scientific research. In other words, when applicants undertake multiple projects, their enthusiasm for scientific research is not as high as those with just one. In addition, due to limited time and energy, it is easier for applicants to focus on fewer projects to produce higher output. In the light of high level output, except remarkable difference in female applicants, there is no obvious distinction among others, which indicates the little difference in high level of output brought by the two groups.

DISCUSSION

The study intends to use back-chaining method to determine what factors of applicants on earth are influencing output performance, so as to promote it by choosing the right trustee with pointed references. On the basis of statistical and test results, significant influencing factors will be focused, while the others (less remarkable) would not be paid much attention to, like gender, affiliations of 985-project universities where applicants belong to, professional title (professor or deputy professor), academic post (New Century Excellent Talents), and post like vice-president etc.

The government should make special funding scheme for researchers between the age of 41 and 45; decrease funding on researchers between the age of 46 and 50; in order to expand social influence, it also needs to extend funding scope of researchers above the age of 50. Research results indicate that the overall and high levels of output brought by the age group of 41-45 are significantly higher than that of other age groups. The conclusion is different from the foreign idea that age group of 36-40 is the golden time for researchers (Kyvik, 1990). This may be caused by the long education cycle in our country or the ethnic difference. But, at least, it indicates that the golden period of researchers in our country is between the age of 41 and 45, in terms of management and social science. Therefore, to promote output performance in these fields, we can establish special scientific project funding program for the age group, and name the program as special support plan for the middle-young age group (41-45). In addition, though researchers above the age of 50 cannot promote high level of output, they can increase the overall output (via improving non-high-level output). In the future, if our country needs research projects pursuing social influence, like study of soft power, Chinese ancient civilization and science population, it can entrust these studies to researchers of this age group. It can also launch a range of special supportive programs with high social influence that aim at scholars and researchers above the age of 50, like special support plan on Chinese ancient civilization research, research project of national soft power export, special support program of big data population and special support plan of determining and inheriting Chinese folk custom. It is explicitly stipulated that these special programs are targeted to researchers above the age of 50.

The government should increase scientific research funding and strengthen assistance towards researchers and scholars from 211-project universities; if China aims to promote high level output performance, then assistance to general universities and institutes should be diminished. In terms of work units, applicants from affiliations of "211-project universities" have a positive significance on promoting overall output and high levels of performance; it indicates that such institutes have better scientific incentive systems and measures that help their researchers to enhance scientific performance. In the future, we can boost the funding rate and assistance towards these personnel in the normal process of project funding, or can also launch funding program aiming at 211-project universities. According to the statistics, high-level of achievements from general universities and other scientific institutes tend to be few. Hence, if scientific funding in the future aiming to pursue high level rather than low level, funds toward researchers in these institutes should be reduced. To motivate these researchers, we can set particular projects that concern less about high level of output.

Discrimination against professional titles should be eliminated in the process of research funding. If the project aims at high level of output, then more funds should be given to researchers with the title of lecturer or the same level; if the project targets to overall output, funds for the research group should be reduced. According to the statistics, both senior title and deputy senior title do not have remarkable impact on overall output and high-level of output, while medium-grade professional title and the others (include primary title and no title) are conductive to promoting high level of scientific output. However, it is also a double-edged sword, since it is adverse to overall output. In the future, if the process of scientific funding aims to pursue high level of output, it should pay more attention to young lecturers who have medium-grade title or no title; but if it targets to promoting overall output (general scientific achievements in particular) and expanding social influence, funds towards these personnel should be reduced.

In the process of scientific funding, funds for academicians and Yangtze River scholars should be reduced, or delete the two groups from the general scientific funding programs. However, money allocated for person selected for New Century Talents Project can be increased. Aiming to promote high-level scientific output, our country can consider raising funds for talents selected for NSF Career Award, but decrease funds for Thousand Talents program. Statistically speaking, academic titles like academician and Yangtze River scholar obviously prevent improving overall output performance and high-level performance, which is consistent with the reality. The two groups are at the top of the academic pyramid in China; they do not have much pressure from life and work, and also lack research motivation. Therefore, in the future, if scientific funding targets to boosting output performance, funds towards the two groups should be reduced or even making policies to prevent them from competing with other ordinary researchers for the limited resources. For instance, academicians and Yangtze River scholars should not be allowed to compete with other researchers for projects from National Natural Science Foundation, Social Science Foundation and Soft Science Foundation. If the country wants to subsidize the two groups, it should promote some exclusive projects for them. It is usual that "One-pot procedure" helps the two groups who have a say in scientific funding to seize the limited resources, which reduces the performance. On the contrary, talents selected for New Century Talents Project are conducive to enhancing overall output and high-level performance, so we can expand the funding scope and strengthen the assistance intensity of the group. If our country aims to maintain high levels of output in the future, funding scope and intensity towards person selected for Career Award can be expanded and strengthened. Statistically speaking, the group is in favor of improving high levels of output. Finalists of Thousand Talents program are obviously adverse to high levels of output, which may be due to the first period of excessive funding (10,000,000 yuan for science and engineering, 5,000,000 yuan for humanities and social science). Overmuch funding dramatically erodes efficiency and utility. If we want to pursue high levels of scientific output, fewer funds should be allocated for the group.

In terms of posts, more funds should be allocated to institute directors, but not to the deputy directors. If aiming to boost overall output of scientific research, support for research group of secretary should be diminished; while, if targeting to enhancing high levels of output, funds for the group of vice-president should be reduced. Statistics show that the group of director is not only helpful to promote overall output, but also high levels of output. The group is a blue chip. Hence, funding scope and funding intensity of the group can be expanded and strengthened. The group of deputy director needs us to continue to observe. Statistical data reveals that they are not helpful in boosting either overall output or high levels of performance. So, we need to fund them with caution. Before they enhance their scientific research capacity, fewer funds should be allocated to them. It is obvious that secretary of party committee cannot improve the overall output. If China aims to boost scientific overall output, support for the group should also be reduced; vice-presidents are apparently adverse to high levels of output, so we need to decrease their funds if we pursue high levels of output.

If China wants to boost overall output, number of projects undertook by one applicant in a certain period should be reduced to one, or the policy that one applicant can only be funded once in a particular time can be implemented. Statistics show that, generally speaking, overall output of applicants who have only done one project is remarkably higher than that of researchers who frequently undertake projects in a short period. This is a typical effectiveness decrease in scientific research. The authorities should make policies to restrict the number of projects that a particular researcher undertakes during a certain period, e.g. forbidden applicants to do over two projects within five years. In the process of selecting applicants, to enhance output performance, priority should be given to researchers with better scientific research background but having never undertaken any project. In particular, to improve funding effectiveness, policy that funding one particular researcher once in a certain period should be implemented, which is also an equalization of public services (Jin & Yuan, 2011). For applicants with general research capacity, the more projects they undertake, and the lower performance they bring. Offering opportunities to the groups with better scientific research capacity is helpful in improving the efficiency of public finance.

The paper uses exploratory and tentative back-chaining method to study the performance factors. Based on the formed output, it explores what factors of applicants on earth are affecting the output performance. In the specific procedures, we sampled scientific research projects with the topic relating to government and belong to social science in nature as the subjects. Whether the findings in these fields of social science embody any feature of science and engineering projects needs further study to verify. Meanwhile, the applicants we chose might belong to the best group or the worst group. The former might mislead the factors contributing to high performance, while the latter might misguide the factors leading to low performance. We still need to expand the sample size to verify the reliability and validity of the result in the future. Moreover, it is common that a scientific research has a long cycle. Projects and their research achievements need longer time to fulfil, which might also affect the credibility. We need to take this into consideration in the future.

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Pre-service Science Teachers' Understanding of Chemistry: A Factorial Design Study

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ABSTRACT

This study compared the effect of the instructional treatments (guided inquiry-based and traditional recipe-like approach) and the learning environments (authentic and virtual learning environments) on pre-service science teachers' understanding of chemistry concepts. For this purpose, Authentic Inquiry-based Laboratory, Virtual Inquiry-based Laboratory, Authentic Recipe-like Laboratory and Virtual Recipe-like Laboratory were designed. Eight laboratory activities related to thermochemistry, chemical kinetics, chemical equilibrium, acids and bases and electrochemistry were developed. Sixty-eight pre-service science teachers were randomly stratified into four equal groups: Authentic Inquiry-based Laboratory, Virtual Inquiry-based Laboratory, Virtual Recipe-like Laboratory and Authentic Recipe-like Laboratory. A two-tier General Chemistry Concept Test developed by researchers was used for the data collection tool before and after the treatment and data were analysed using nonparametric statistical methods. According to the results there was a significant difference between post test scores of groups and this difference was between Authentic Inquiry-based Laboratory and Authentic Recipe-like Laboratory, Virtual Inquiry-based Laboratory and Authentic Recipe-like Laboratory. Mean scores of groups were arranged from the highest to the least as Authentic Inquiry-based Laboratory, Virtual Inquiry-based Laboratory, Virtual Recipe-like Laboratory and Authentic Recipe-like Laboratory. Each item of the test was also analysed and changing of alternative conceptions was assessed. Decreasing of frequencies of alternative conceptions were generally arranged same as mean scores except for chemical kinetics.

Keywords: guided inquiry-based learning; understanding of chemistry concepts, virtual laboratory

INTRODUCTION

For the last decades, science educators have emphasized the necessity of students to acquire knowledge by themselves via investigation, thinking scientifically like a scientist, not only to prove scientific facts but also to inquire these facts. Doing experiment is one of the most important ways for questioning of scientific facts like a scientist; therefore, laboratory instructions for training students have came into prominence.

Laboratory instructions take an important place in science education because science subjects cannot be learned meaningfully without laboratory instructions (Hofstein & Lunetta, 1982, 2004; Hofstein & Mamlok-Naaman, 2007; Tobin, 1990). In addition, the laboratory instructions are effective in the understanding of science concepts, improving scientific process skills and problem-solving skills (Hofstein & Mamlok-Naaman, 2007; Lunetta, 1998). Moreover, the laboratory instructions enable the students to use more than one of their sense organs to investigate

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Contribution of this paper to the literature

- There is limited research that evaluates understanding by using a two-tier diagnostic test and there is no study uses a 2 x 2 factorial design. This study was aimed to investigate the effect of the instructional treatment (guided inquiry-based and traditional recipe-like approach) and the learning environments (authentic and virtual learning environments) on the pre-service science teachers' understanding using 2 x 2 factorial design.
- According to the results, the guided inquiry-based approach was more effective than the traditional recipe-like approach both authentic and virtual laboratory environments on the pre-service science teachers' understanding and remedying of alternative conceptions.
- An authentic laboratory environment was more beneficial than a virtual environment when it was supported by guided inquiry-based learning; virtual environment was more effective than authentic laboratory environment when it was based on the traditional recipe-like approach.

events and materials directly, to make them active in the learning process, to develop their research and investigation skills, to apply their learning to daily life and to observe repeatedly (Karamustafaoglu & Yaman, 2010).

Authentic Laboratory vs Virtual Laboratory

Although the laboratory has many benefits, there are some limitations to using it, such as sharing a laboratory with different courses, negative attitudes of teachers about laboratory management, crowded classrooms, using dangerous and expensive chemicals/materials/equipment, long and dangerous experiments (Altun et al., 2009). In recent years, virtual laboratories have become popular to overcome these limitations (Altun, Feyzioglu & Demirag, 2011; Tuysuz, 2010). Virtual laboratories are defined as environments that give a chance to students to do an experiment for turning their theoretical knowledge into practice by performing the simulation of a real laboratory (Woodfield, 2005). In the virtual laboratory, learning can be out of a classroom and instructions become more dynamic when a computer is available (Yang & Heh, 2007). They have provided a learning environment that is interactive, safe and independent of time and classroom (Altun et al., 2011; Dalgarno, 2015; Tuysuz, 2010). Students can stop, resume and repeat the experiment (Gershenson, Gonzalez, & Negrete, 2000), therefore they have an opportunity to conduct the experiment according to their individual learning (Stieff & Wilensky, 2003). In addition, virtual laboratories enable simulation of both macroscopic and microscopic properties of chemical reactions, concurrently (Tuysuz, 2010). Some chemical reactions may occur very fast, very slow or in a very complex way and virtual laboratories make it possible to observe these reactions (Singer, Hilton, & Schweingruber, 2006). Moreover, students can conduct a dangerous, long and expensive experiment in these laboratories in a safe learning environment (Dalgarno, Bishop, & Bedgood, 2003; Gershenson et al., 2000; Kamlaskar, 2007). Students can become familiar with the experimental process (Georgiou, Dimitropoulos, & Manitsaris, 2007), and both communication and interaction can be promoted by using this virtual environment (Lily et al., 2008; Yang & Heh, 2007). On the other hand, students in the virtual laboratory virtually complete experiments, as if they were in an authentic laboratory environment, they could not use and improve their psychomotor skills in the virtual environment (Carnevale, 2003; Diker, 2011). They also do not touch laboratory materials, have interaction with laboratory materials and chemicals and they pay minimal attention to safety rules (Bucos, Dragulescu, & Ternauciuc, 2008).

In recent years, the demand for virtual laboratories has increased because they have overcome real laboratories limitations and the research that investigates laboratory instructions has focused on the effects of virtual laboratory environments (Altun et al., 2011; Bakar & Zaman, 2007; Bozkurt, 2008; Bucos et al., 2008; Carnevale, 2003; Diker, 2011; Hawkins & Phelps, 2013; Jezierska, Podraza, Domek, & Szwed, 2016; Kennepohl, 2001; Mercer-Chalmers, Goodfellow, & Price, 2004; Tatli, 2011; Trindade, Fiolhais, & Almedia, 2002; Tuysuz, 2010; Yang & Heh, 2007). In a highlight of these studies, it was emphasized following situations about virtual laboratories: Traditional recipe-like laboratories have some limitations such as safety problems, long and dangerous experiments, expensive chemicals and equipment, the necessity of a place and obligation of conducting an experiment fixed time. Because of these limitations, laboratory instructions are not accomplished using their full potential efficiently. Considering these situations, in the virtual laboratory studies, more dynamic, independent of place and time, interactive learning environments were presented to participants. Participants conducted an experiment actively, they could repeat the whole experiment or any step. Therefore, they had the opportunity to conduct them at their individual learning pace and convenience. They could also observe microscopic levels of the experiment. As a result of these, achievement and performance were promoted and students felt relax, less tired and safer. They also became familiar with the experimental process, chemicals and equipment students could focus on the experiment rather than the use of chemicals/equipment, the danger of experiment or cost. These advantages enhanced students' inquiry skills, high-level cognitive skills, motivation and interest. However, these virtual laboratories could not provide some opportunities of authentic laboratories as mentioned previous paragraph.

Inquiry-based Learning Approach and Laboratory Applications

One of the limitations of laboratory instructions is having to carry out the laboratory activities in a particular sequence. However, science educators have discussed the inadequacies of traditional cook-book laboratory instructions for many years. For example, the students who conducted traditional cook-book laboratory activities focus on carrying out an experiment by following the directions. In addition, these directions have more details and this situation leads to misunderstanding the experiment's aim (Johnstone & Wham, 1982). In addition, the students prove scientific facts without discussing them in traditional cook-book laboratory activities (Roth, 1994). Therefore, they do not understand the aim of experiment and related learning issues (Hofstein & Lunetta, 2004). Moreover, the students in both science classes and science laboratories think that knowledge in a book and other sources is enough and they do not inquire into this knowledge's source. However, inquiring is an important component of science program at each level and in each area (Crowther, 1999). For this reason, inquiry-based learning takes an important place in science education.

Inquiry-based learning is expressed as activities that are improved by students' knowledge and in which they learn how scientists work (NRC, 2000). This approach which ensued in the light of constructivist approach attaches great importance to research process rather than problem solving (Lim, 2001). In addition, an inquiry-based learning approach provides an opportunity to improve students' scientific content knowledge, their perceptions about the nature of science and their inquiring skills for using it (NRC, 2000). Moreover, students have another opportunity to get an understanding of fundamental concepts and theories, comprehending of facts and events, improving questioning and answering (Chiappetta & Adams, 2004). Briefly, science education turns from watching and listening activities to doing activities (Hinrichsen & Jarrett, 1999).

Inquiry-based learning was first classified into three levels by Schwab according to activeness of teacher and students (Schwab, 1962). Then, these levels were revised and new levels were added to them. These levels are confirmation inquiry, structured inquiry, guided-inquiry, double inquiry and open inquiry. While students are the most active in open inquiry, the teacher is the most active in confirmation inquiry. In guided inquiry, a problem is given to students by the teacher and they investigate methods and solutions under the guidance of a teacher (Colburn, 2000).

Inquiry-based learning is more effective in laboratory instructions because laboratories are environments in which you can teach to invent and ways of achieving knowledge rather than to prove the knowledge. In the inquiry-based laboratory, students do not follow directions step by step and they have an opportunity to work in a small cooperative group, to increase their responsibility (Coppola & Lawton, 1995), to be familiar with planning and conducting research and to conduct new research easily by this way (Wimmers, 2001). Basically, an inquiry-based laboratory experiment has two phases: Pre-inquiry and inquiry (Hofstein, Shore, & Kipnis, 2004). In the pre-inquiry phase, students carry out a short experiment to focus on the inquiry process. In the inquiry phase, they formulate hypothesis/hypotheses by asking relevant questions and they choose one of them to investigate. Then, they plan and conduct an experiment to prove their hypothesis/hypotheses. In this process, they note their observations and results obtained from the experiment. Finally, they discuss whether the hypothesis is accepted or not among their group members and they present their results in a scientific way (Hofstein et al., 2004).

Inquiry-based learning has many benefits in the learning process, but inquiry-based activities are limited (Cheung, 2008). Furthermore, inquiry-based laboratory research on students' understanding at the undergraduate level and especially at the teacher training level is limited (e.g. Akben, 2015; Almuntasheri, Gillies, & Wright, 2016; Buckner & Kim, 2014; Franklin et al., 2015; Hemraj-Benny & Beckford, 2014; Hsiao et al., 2017; Kaya & Yilmaz, 2016; Ozkan & Bumen, 2014; Ramnarain, 2014; Yetişir, 2016).

In this study, the pre-service science teachers' understanding of chemistry concepts, namely, chemical kinetics, chemical equilibrium, thermochemistry, acids-bases and electrochemistry was investigated. For this purpose, four different learning environments were designed. According to the literature review, there is limited research inquiry-based laboratory, virtual chemistry laboratory, inquiry-based virtual chemistry laboratory studies for students' understanding related to the aforementioned concepts at the undergraduate level and especially at the teacher-training level are limited. In addition to these, there is much research that assessed the effect of only instructional treatment of mentor-only learning environment on different variables. Although there is some research focused on only one chemistry topic, this research focused on five chemistry topics and it was conducted during one semester. Our research differentiated from other research with these aspects and it will make a major contribution to the literature in this respect.

Understanding of teachers has a great role in students' meaningful understanding. Chemistry concepts also have great place in a science subject. If a teacher has alternative conceptions, they will teach them to their students.

For this reason, training of pre-service teachers and remedying their alternative conceptions have a major importance. For this purpose, different and effective learning environments should be prepared and evaluated especially at the teacher-training level.

Purpose of the Research

This study to investigate the effect of instructional treatments (guided inquiry-based and traditional recipe-like approach) and the learning environments (authentic and virtual learning environments on the pre-service science teachers' understanding. The following research question was investigated in this study:

Do the instructional treatments and the learning environments affect the pre-service science teachers' understanding of chemistry concepts?

METHOD

Participants

This study was conducted with the participation of 68 pre-service science teachers (19-22 years) in an education faculty in Istanbul, Turkey. All the participants had learned basic chemistry concepts in the General Chemistry course in the first semester. They had also learned laboratory rules, laboratory safety, and laboratory methods.

The pre-service science teachers were stratified according to the pre-test scores obtained from the General Chemistry Concept Test, gender and age, and then they were randomly assigned to four groups (**Table 1**): Authentic Inquiry-based Laboratory (AIL), Virtual Inquiry-based Laboratory (VIL), Virtual Recipe-like Laboratory (VRL) and Authentic Recipe-like Laboratory (ARL).

Table 1. The distribution of pre-service science teachers

		AIL	VIL	VRL	ARL
Pre-Test Results of General Chemistry Concept Test	Low (4-8)	6	5	6	6
	Medium (9-12)	5	6	6	6
	High (13-16)	6	6	5	5
Gender	Female	14	14	15	14
	Male	3	3	2	3
Age	19	14	13	15	14
	19+	3	4	2	3

Ethical Procedures

This study was conducted with the participation of 68 pre-service science teachers (19-22 years). Before the research, the participants were informed about the study. For this purpose, a guide form was prepared by the researcher containing headings:

- Heading of the research
- Aim of the research
- Importance of the research
- Basic steps of the research
- Ethical explanations

In the ethical explanation section, it was explained that there was no obligation or sanction for participating in the research. After reading the form, the participants declared that they volunteered for the study by signing this form.

This study was conducted using chemical and laboratory equipment. For this reason, brief information was given to participants about laboratory safety rules. The instructor also took precautions before each activity for protecting the participants from harm.

The last point of ethical procedure was the gatekeeper of the research. Because one of the researchers was the instructor of the lesson at the same time, activities were conducted by the instructor. In addition, the other researcher made observations during the instructions.

Instruments

General Chemistry Concept Test. To determine the pre-service science teachers' understanding before and after the instructions, a two-tier diagnostic General Chemistry Concept Test (GCCT) developed by researchers based on Treagust's method (1988), in which 44 items related to thermochemistry, chemical kinetics, chemical equilibrium, acids-bases and electrochemistry, was used First, content boundaries and the learning objectives were determined. Alternative conceptions were derived both from literature review and the pre-service science teachers' semi-structured interviews. Then, a multiple-choice test with an open ended part, in which the pre-service science teachers were required to explain their reason for their answers to the first part, was constructed and applied to the 68 pre-service science teachers. Their responses to the open-ended part of each item were analysed, these results and alternative conceptions derived from the literature were used for constructing the distracters. Hence, the two-tier test was constructed in a way that the first tier included a conventional multiple-choice step and the second tier included possible reasons of the given answer for the first tier. For the content validity, the test was reviewed by five chemistry educators and it was applied to 151 pre-service science teachers. According to the item analysis results, two items were removed from the test because of having negative discrimination indices. The difficulty levels were 0.3 and 0.77 with an average of 0.50; discrimination levels were identified between 0.2 and 0.64 and average of them was calculated as 0.39. For reliability analysis, Cronbach's alpha reliability coefficient was calculated and reported because coefficient alpha is equivalent to the Kuder-Richardson 20 coefficient for dichotomous data (Green & Salkind, 2005). The final version of the two-tier diagnostic test consisted of 44 items and the language of the test was Turkish. The Cronbach α reliability coefficient was found to be 0.84 (**Table 2**) and this value was high and acceptable when compared with the literature values (e.g. Chandrasegaran, Treagust & Mocerino, 2007; Tsui & Treagust, 2010). Answer all the questions on the test took nearly 90 minutes.

Table 2. Test topics and items

Topic	Items
Thermochemistry	Q6, Q15, Q24, Q35, Q41, Q44
Chemical Kinetics	Q1, Q4, Q7, Q8, Q10, Q11, Q12, Q14, Q16, Q18, Q38
Chemical Equilibrium	Q27, Q30, Q32, Q34, Q36
Acids and Bases	Q2, Q5, Q9, Q13, Q17, Q19, Q20, Q21, Q23, Q25, Q28, Q29, Q31, Q37, Q42, Q43
Electrochemistry	Q3, Q22, Q26, Q33, Q39, Q40

Research Design

In the present study, the effectiveness of the guided-inquiry approach and traditional recipe-like approach in different learning environments on the pre-service science teachers' understanding was compared. Therefore, participants were stratified into four groups and 2 x 2 factorial design, in which the instructional treatment and learning environment were adopted as independent variables, was used (**Table 3**). The pre-test and post-test with control group design was modified in this research design and it provided an assessment for both the separate effects of each independent variable and their joint effects (Fraenkel, Wallen, & Hyun, 2012). This research design allows researchers to assess the interaction of a variable with one or more other variables and each variable has two levels (Fraenkel, Wallen, & Hyun, 2012). In this study, both instructional treatment (guided inquiry approach and traditional recipe-like approach) and learning environment (authentic and virtual environment) had two levels. Participants were stratified into four groups and 2 x 2 factorial design, in which the instructional treatment and learning environment were adopted as independent variables, was used (**Table 3**). Guided inquiry-based laboratory activities were conducted in AIL and VIL in the authentic and virtual environments, respectively. VRL and ARL performed traditional recipe-like laboratory activities in the virtual environments and authentic environments, respectively. Instructions in all groups were conducted during eight weeks and the GCCT was applied before and after the instructions.

Table 3. Research design used in the study

		Learning environment	
		Authentic Laboratory (AL)	**Virtual Laboratory (V)**
Instructional treatment	Guided Inquiry Approach (GIA)	Authentic Inquiry-based Laboratory	Virtual Inquiry-based Laboratory
	Recipe-like Approach (RA)	Authentic Recipe-like Laboratory	Virtual Recipe-like Laboratory

Instructional Treatment

In the present study, eight laboratory activities related to chemical kinetics, chemical equilibrium, thermochemistry, acids-bases and electrochemistry were developed (**Table 4**).

Table 4. Distribution of laboratory activities according to subjects

Number of Experiment	Subjects	Aim of laboratory activities
1	Chemical Kinetics	Identification of effect of surface, temperature, stirring and amount of substance on reaction rate
2	Chemical Kinetics	Identification of the effect of catalyst on reaction rate
3	Chemical Equilibrium	Identification of the effect of temperature and concentration on equilibrium reaction
4	Thermochemistry	Identification of heats of dissolution and neutralization
5	Acids and Bases	To calculate the degree of acidity by titration
6	Acids and Bases	To comprehend the buffer mechanism
7	Electrochemistry	Identification of the effect of concentration on cell potential
8	Electrochemistry	Identification of the ways of removing rust and corrosion prevention

In the first step of developing the laboratory activities, the literature was reviewed and the pre-service science teachers' understanding and learning difficulties were determined. After the learning objectives were identified, the laboratory activities were prepared properly for both guided-inquiry-based and traditional recipe-like approaches. Before the instruction, all the pre-service science teachers were informed about the learning process with a brief orientation including group rules, student and instructor roles, and assessment criteria. All the pre-service science teachers conducted the same laboratory activities in a different manner under the guidance of the instructor. While the pre-service science teachers in the authentic laboratory environment performed physical manipulation of equipments themselves under the guidance of an instructor, the pre-service science teachers in the virtual environment virtually complete this process as if they were in an authentic laboratory environment.

Authentic Inquiry-based Laboratory. The pre-service science teachers (*N* = 17) were randomly assigned to four cooperative groups for conducting the laboratory activities based on the guided-inquiry approach in an authentic laboratory laboratory environment. In addition, laboratory worksheets were prepared according to the stages of the inquiry-based laboratory activity mentioned by Hofstein, Shore and Kipnis (2004). These worksheets had two phases and seven steps, which are presented in **Table 5**.

Table 5. Laboratory worksheets based on guided-inquiry approach in this study

Phases	Steps	Pre-service science teachers' requirements
Pre-inquiry	A brief story about daily life, connected with the learning issues	Read the story in a detailed manner, to discuss and inquire the situation given in the story
Inquiry	Define your problem	Define the problem given in the story
	Define your hypothesis	Define hypothesis/hypotheses for the solution of the problem situation given in the story
	Collect data	Design an experiment to prove the hypothesis by using laboratory materials/chemicals that were given in worksheets or the others that you want to use.
	Write your experimental steps	Write the experimental procedures for the experiment planned by the pre-service science teachers.
	Results	Write the results obtained from the experiment. In addition, draw a graph and present tables for results (if it is necessary)
	Interpretation	Interpret findings and associate them with the problem and hypothesis. If the hypothesis is not proved by the results, the experiment needs to be re-planned and re-done in this step

All worksheets were reviewed by four chemistry educators, and they were piloted by the participation of five pre-service science teachers. Unless the instructor confirmed the pre-service science teachers' writings, they could not pass onto the next step.

As an example, the schematic representation of a guided-inquiry-based laboratory activity worksheet, related to chemical equilibrium topic, is presented in **Figure 1**. The purpose of the activity was the identification of the effect of temperature and concentration on the equilibrium reaction. In this activity, a brief daily life story was given to the pre-service science teachers. The story was about solving a problem based on a laboratory accident. In the story, a student prepared $CoCl_2$and HCl solution and she poured HCl onto $CoCl_2$, accidently. Then, she observed that solution's colour turned from pink to blue. So, the pre-service science teachers inquired other ways of turning the solution's colour from pink to blue and from blue to pink as mentioned in the story.

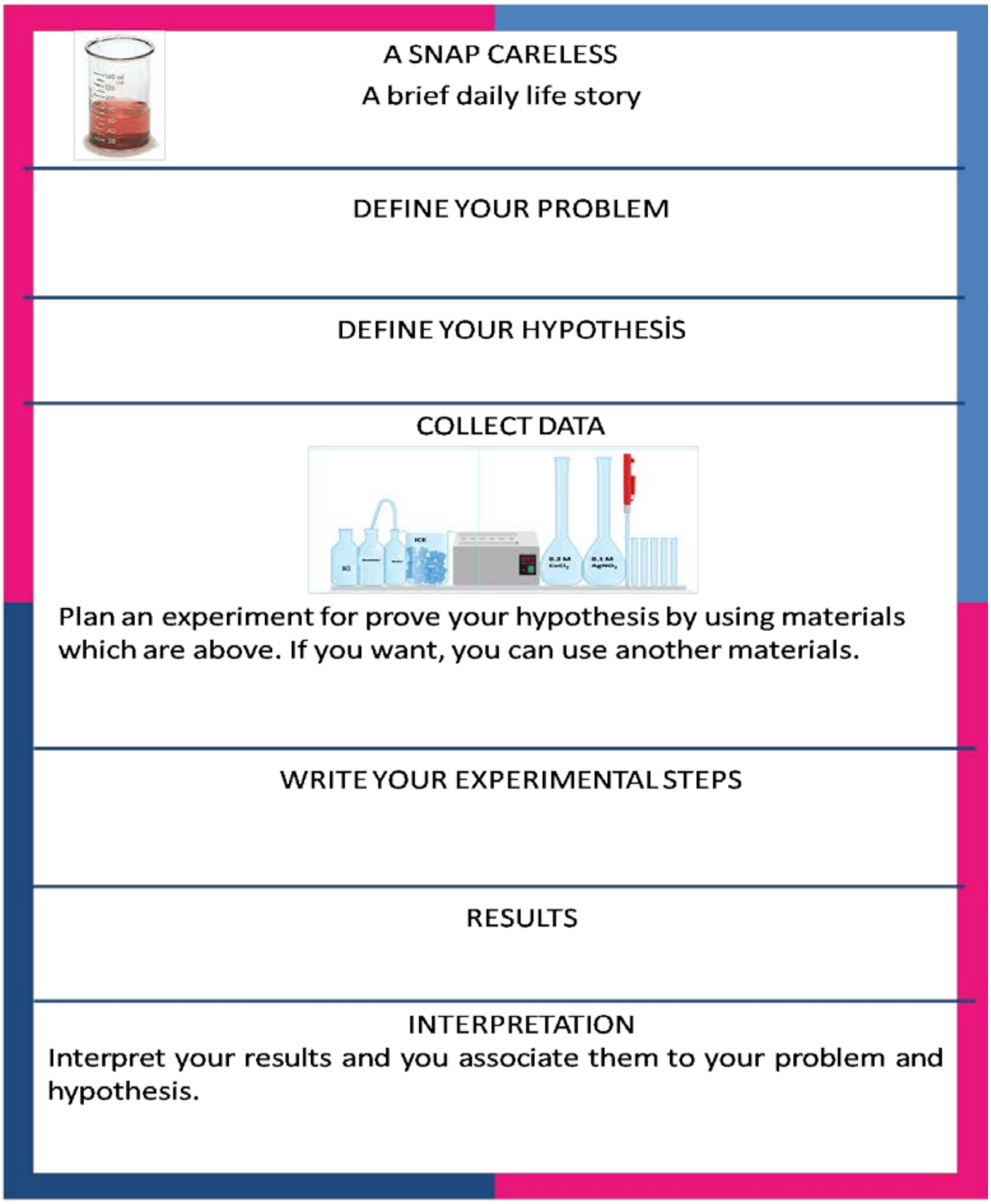

Figure 1. A schematic representation of the worksheet

In this story, the reason for choosing a reaction that changed colour by effects was making concrete the effects on equilibrium. During the discussion in all the steps of the activity, the instructor was a guide to prevent misleading the pre-service science teachers. In the first step of this activity, the pre-service science teachers read and discuss the story. In the second step, they were required to define the problem given in the story. In this step, they first discussed the type of reaction given in the story. After they had identified the reaction type as an equilibrium reaction, they discussed the reason for the colour change. After the discussion, the pre-service science teachers were required to identify the problem situation, what other ways of colour changing in this equilibrium reaction. In the context of the problem, they actually discovered factors affecting equilibrium. After confirmation of the problem, they defined their hypothesis in the third step and they planned an experiment related to chemical equilibrium to prove their hypothesis. In this step, concentrated HCl, acetone, water, ice, water bath, 0.2 M $CoCl_2$, 0.1 M $AgNO_3$, some pipettes and some test tubes were given to the pre-service science teachers and they were required to design an experiment using these materials or the other laboratory materials and chemicals that they wanted. Then, they carried out the experiment. They had an opportunity to observe the effects of temperature and concentration on equilibrium reaction of $CoCl_2$ and HCl. During the activity, they recorded their observations and findings in their worksheet. Lastly, they discussed their findings, they associated their results with the problem and hypothesis defined at the beginning of the activity and they shared the results with their classmates.

Virtual Inquiry-based Laboratory. The pre-service science teachers (*N* = 17) were randomly stratified into four groups for conducting the laboratory activities based on the guided-inquiry approach in a virtual laboratory environment. In the present study, two software programs were developed: Guided-Inquiry-based Virtual Chemistry Laboratory (GIBVL) software for the pre-service science teachers and Instructor Software for the instructor. In GIBVL, the same guided-inquiry based laboratory activities as in AIL were computerized to a virtual environment. In addition, GIBVL was developed based on the Analysis, Design, Development, Implementation, and Evaluation (ADDIE) instructional design model (**Table 6**).

Table 6. Development process of GIBVL based on ADDIE model

Steps of the model	Implementations
Analysis	Basic properties of GIBVL and development standards were identified. Experiments were conducted in a real environment and they were recorded for identification of software content, steps of experiments and real experimental data. Virtual laboratory applications were examined. Web sites and books were examined for modelling the software interfaces, experimental materials and equipment. Use of HTML5, CSS3, PHP, MySQL, Adobe Flash Action Script 3.0, jQuery programs and applications were decided.
Design	Guided inquiry approach was added to the software. Completion criterias for activities were identified.
Development	Software was developed according to the steps of the guided inquiry approach. A periodic table, calculator, laboratory rules, about the study and help sections were added to the software for the pre-service science teachers. A notebook was added to the GIBVL software to allow the pre-service science teachers to write their observations and findings.
Implementation	Software was activated on the Internet User name and password parts were added to the software. Experts were identified for reviewing. The pre-service science teachers were identified for piloting the applications.
Evaluation	The software was reviewed by two chemistry and one computer educators and then it was revised. Pilot applications were done with the participation of five pre-service science teachers and the software was revised. The software was reviewed by the experts again and the final version of the software was developed.

The pre-service science teachers carried out guided-inquiry-based virtual laboratory activities using GIBVL. These virtual activities had the same steps as AIL, in which there was a brief story about daily life, defining the problem, defining the hypothesis, collecting data, writing experimental steps, results and interpretation. In addition, the instructor confirmed or refused the pre-service science teachers' problem, hypothesis etc. using instructor software. Unless the instructor confirmed their writings, learners could not pass on to the following step.

Moreover, the instructor could send short guiding sentences about accomplishing steps and the reason for their refusals. So, the pre-service science teachers had an opportunity to communicate with the instructor and correct their errors in this way.

As an example, a GIBVL activity related to the chemical equilibrium topic is presented in **Figure 2**. A brief daily life story which was the same as in AIL was given at the beginning of this activity. After the pre-service science teachers had read the story, they were steered to define the problem and send it to the instructor software. The pre-service science teachers sent their writing to the instructor software; the instructor could confirm or refute it. After the pre-service science teachers' problems and hypothesis had been confirmed by the instructor, they were required to plan an experiment. After the instructor had confirmed the pre-service science teachers' plan of the experiment, they were steered to conduct the experiment planned by them. After the pre-service science teachers had completed each level of the experiment, they were required to take notes, such as steps of the experiment, their observation or findings on the notepad in GIBVL. Unless they took notes, they could not move on to the next step of the experiment. So, they were encouraged to take notes in this way. At the end of the activity, the pre-service science teachers were steered to send their results to the instructor to be confirmed. If their results were refused, they could repeat step/steps that they wanted. After their results had been confirmed, they associated their results with their problem and hypothesis and they sent it back to the instructor to be confirmed. After the confirmation, they could complete the activity.

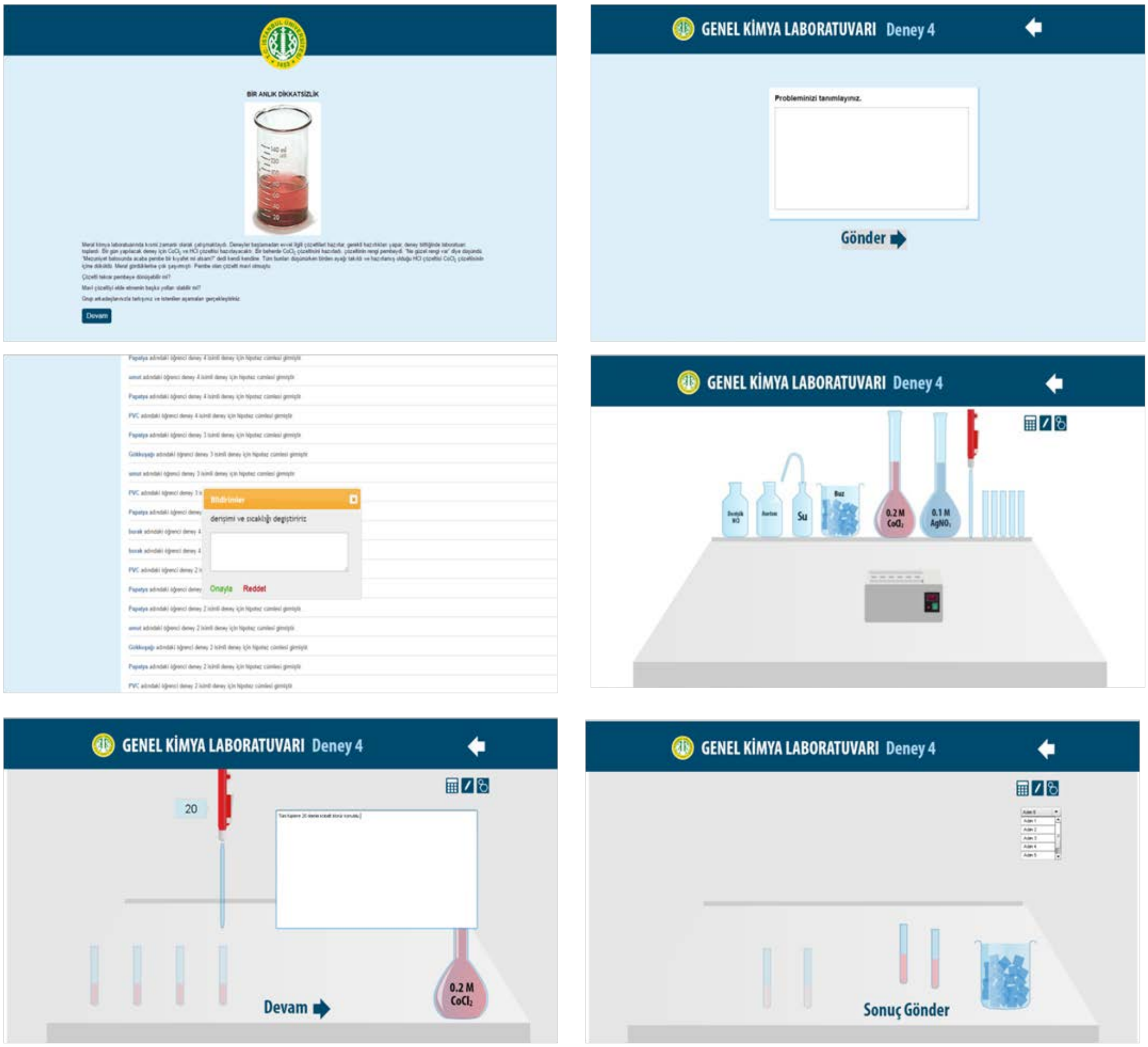

Figure 2. Interface of different steps in guided-inquiry based virtual laboratory

Virtual Recipe-like Laboratory. In VRL (*N*=17), the pre-service science teachers were randomly stratified into four groups for conducting the laboratory activities based on a traditional recipe-like approach in a virtual laboratory environment. For this purpose, traditional recipe-like learning approach based virtual chemistry laboratory software (TABVL) was developed. While TABVL was being developed, the same procedure that had been used to develop GIBVL was conducted according to the ADDIE instructional model (Table 7).

Table 7. Development process of TABVL based on the ADDIE model

Steps of the model	Implementations
Analysis	Basic properties of TABVL and development standards were identified. Experiments were conducted in a real environment and they were recorded for identification of software content, steps of experiments and real experimental data. Virtual laboratory applications were examined. Web sites and books were examined for modelling the software interfaces, experimental materials and equipment. Use of HTML5, CSS3, PHP, MySQL, Adobe Flash Action Script 3.0, jQuery programs and applications were decided.
Design	The traditional recipe-like approach was added to the software. Completion criteria for activities were identified.
Development	Software was developed according to traditional recipe-like approach. A laboratory guide including the name of the experiment, aim of experiment, materials/chemicals list, and steps of the experiment was added to software for each activity. A periodic table, calculator, laboratory rules, about the study and help sections were added to the software for the pre-service science teachers. A notebook was added to the TABVL software to allow the pre-service science teachers to write their observations and findings
Implementation	Software was activated on the Internet User name and password part were added to the software. Experts were identified for reviewing. The pre-service science teachers were identified for pilot applications.
Evaluation	The software was reviewed by two chemistry and one computer educators and then it was revised. Pilot applications were done with the participation of five pre-service science teachers and software was revised. The software was reviewed by the experts again and the final version of the software was developed.

In TABVL, the same laboratory activities were conducted with AIL and VIL. However, experiments directly began in this software and the pre-service science teachers carried out these experiments by following the laboratory guide step by step.

A TABVL activity related to the chemical equilibrium topic is presented in **Figure 3**.

Figure 3. Interface of conducting experiment

In this activity, the pre-service science teachers began the experiment directly. At the beginning of the activity, the pre-service science teachers were steered to read the laboratory guide in TABVL. They followed the laboratory guide step by step during the experiment. In addition, they were required to take notes about their observations and findings during the experimental process as in GIBVL.

Authentic Recipe-like Laboratory. In ARL (N = 17), the pre-service science teachers were randomly stratified into four groups for conducting the laboratory activities based on the traditional recipe-like approach in an authentic laboratory environment. For this purpose, laboratory guides based on the traditional recipe-like approach were prepared for each activity. In these laboratory guides, the name of the experiment, the aim of the experiment, a list of materials and chemicals and steps of the experiment were presented to the pre-service science teachers. In addition, they could write their observations and findings on to these guides.

As an example, a schematic representation of a laboratory guide related to the chemical equilibrium topic is presented in **Figure 4**.

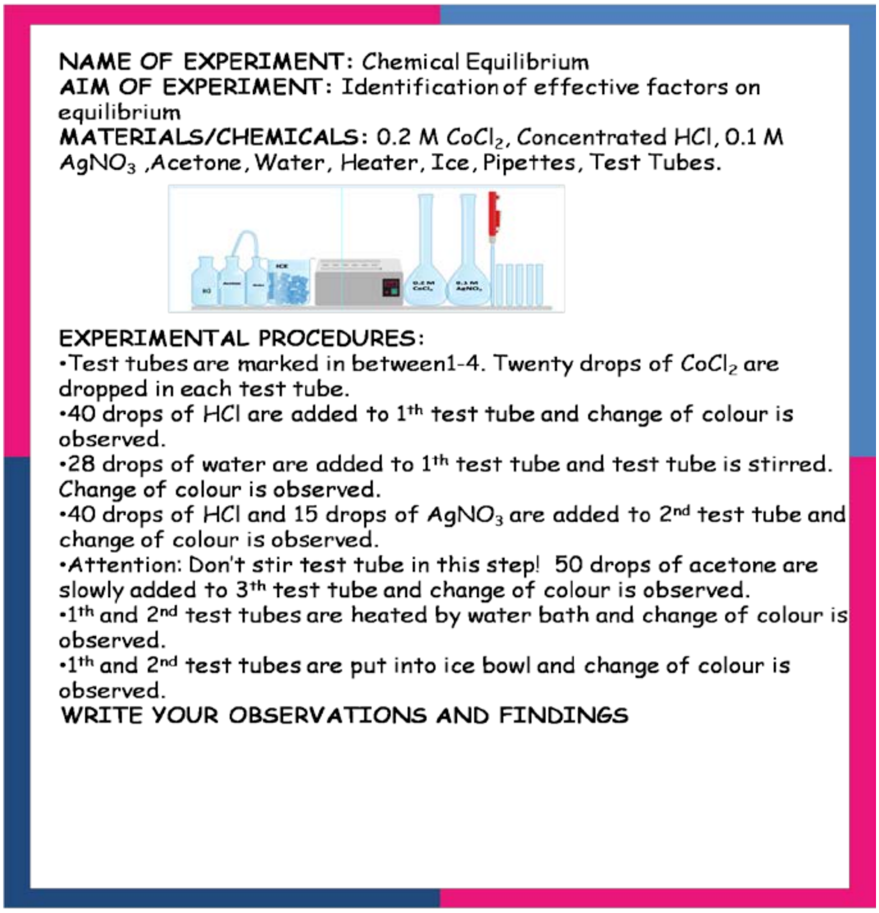

Figure 4. Schematic representation of a laboratory guide related to the chemical equilibrium topic

In this activity, the pre-service science teachers were required to follow these laboratory guides step by step. Therefore, they read the guide clearly and they prepared the laboratory materials and chemicals as given in it. While they were conducting the experiment, they took notes about their observations and findings in the laboratory guide.

Data Analysis

While the GCCT was being analysed, the total score was first calculated. For this purpose, each item was considered to be correctly answered if first tier and second tier were correctly chosen (Treagust, 1988). Therefore, one point was given for items only when both parts of the item were correctly answered, and zero points were given for items when either part was incorrectly answered. This scoring made possible the decreasing of the percentage of students' obtaining a correct answer by chance (Tsui & Treagust, 2010) and evaluated meaningful understanding, deeply.

The pre-test and post- test mean scores of all the groups were compared using nonparametric statistical methods, Kruskal-Wallis H, Mann Whitnet-U and Wilcoxon Signed Ranks, because the actual size of the population is small. The Bonferroni adjustment was also used for Mann-Whitney U test and α was calculated as 0.0083 by split 0.05 to six (Green & Salkind, 2005). The effect size was calculated for comparison by using $r = z\sqrt{N}$ (Pallant, 2007).

In addition, each item of the GCCT was analysed by the following Treagust method (1988) for identifying the pre-service science teachers' alternative conceptions and conceptual change. For this reason, the frequency of each option in the GCCT was calculated in the pre-test for each group and alternative conceptions were identified. Then, these alternative conceptions were examined in the post-test and their frequency variation was reported.

An example item related to acids and bases is presented to illustrate how the item worked and how the data were analysed by the researcher by the following Treagust method (1988).

Which of the following is true about indicators?

a) They increase the rate of reaction.

b) They decrease the rate of reaction.

c) They are strong acid or base.

d) They are weak acid or base.

BECAUSE;

A) They provide colour change by neutralization of acid or base.

B) Indicators provide an alternative way for the reaction to happen which has a lower activation energy.

C) When acid or base are added, they can change colour in different pH range because they give equilibrium reaction based on changing of colour.

D) They decrease the yield of reaction by disrupting the reactants' structures.

E) They increase activation energy of the reaction.

This item assessed the pre-service science teachers' understanding of indicators and their mechanism. While this item was analysed, the frequency (f) of each option of the item was calculated in the pre-test (**Table 8**).

Table 8. Analysis of an acids and bases-related item in the pre-test for identifying the pre-service science teachers' understanding in AIL

N	First Tier (f)	Second Tier (f)					
		A	B	C	D	E	No reason
17	a (2)	-	-	-	-	-	2
	b (11)	-	6	2	-	-	3
	c (0)	-	-	-	-	-	
	d (3)	-	-	1*	-	-	2
	No choice (1)	-	-	-	-	-	1
Total		-	6	3	-	-	8

Note * The correct choice and reason response
- No responses in this category

Most of the pre-service science teachers in AIL (8) gave no response. A small part of the pre-service science teachers in AIL correctly responded to the first tier 'They are a weak acid or base'. In addition, some of the pre-service science teachers in AIL (3) correctly responded to the second tier. However, only one pre-service science teacher selected the correct choice for each tier: (d) for the first tier and (C) for the second tier. Moreover, two of the three pre-service science teachers who selected the correct answer in the first tier gave no reason in the second tier. So, only one pre-service science teacher correctly understood indicators and some of their features. In addition, two pre-service science teachers selected choice (a) and 11 pre-service science teachers selected choice (b) in the first tier and six pre-service science teachers selected choice (B) in the second tier, respectively. According to the results, the following alternative conceptions about indicators were determined in the pre-test:

Indicators increase the rate of reaction ($f = 2$).

Indicators decrease the rate of reaction ($f = 11$).

Indicators provide an alternative way for the reaction to happen which has a lower activation energy ($f = 6$).

In addition, the variation of these alternative conceptions' frequencies was calculated in the post-test to assess the pre-service science teachers' understanding and conceptual change. For this purpose, the options that included these alternative conceptions were examined in the post-test and their frequencies were reported (**Table 9**). The pre-test and post-test of all groups were analysed in similar ways and findings are presented in the Results and Discussion section.

Table 9. Understanding of the pre-service science teachers in AILabout indicators

Alternative Conceptions	Pre-test (*f*)	Post-test (*f*)
Indicators increase the rate of reaction.	2	2
Indicators decrease the rate of reaction.	11	1
Indicators provide an alternative way for the reaction to happen which has a lower activation energy.	6	3

RESULTS AND DISCUSSION

The GCCT was applied before and after the instructions as in pre-test and post-test. The descriptive statistics of the pre-test and post-test GCCT are presented in **Table 10**.

Table 10. Descriptive Statistics of the Pre-test and Post-test GCCT

Group	Test	Mean	Standart Devision	Minimum Score	Maximum Score
AIL	Pre Test	8.76	3.73	5.00	16.00
	Post Test	15.29	4.36	7.00	27.00
VIL	Pre Test	8.82	3.49	5.00	15.00
	Post Test	15.06	2.70	12.00	22.00
VRL	Pre Test	8.71	2.73	4.00	12.00
	Post Test	12.65	3.24	8.00	20.00
ARL	Pre Test	7.94	2.51	4.00	12.00
	Post Test	9.59	2.94	6.00	16.00

In order to compare pre test and post test scores of groups, Kruskal Wallis H Test was used (**Table 11**).

Table 11. Kruskal Wallis H Test Results

Test	Group	N	Mean Rank	sd	χ^2	p
Pre test	AIL	17	34.53	3	0.618	0.892
	VIL	17	35.59			
	VRL	17	36.41			
	ARL	17	31.47			
Post test	AIL	17	44.65	3	24.382	0.000
	VIL	17	45.47			
	VRL	17	31.35			
	ARL	17	16.53			

According to Kruskall Wallis H Test Results, while there was no significant difference between pre-test scores of groups [$\chi 2(sd=3, n=17)= 0.618, p>0.05$], there was significant difference between post test scores of groups [$\chi 2(sd=3, n=17) = 24.382, p<0.05$]. For identification of differences between post test score of groups Mann Whitney U test were conducted (**Table 12**).

Table 12. Mann Whitney U Test Results

Group	N	Mean Ranks	Sum of Ranks	U	p
AIL	17	17.62	299.50	142.500	0.945
VIL	17	17.38	295.50		
AIL	17	21.09	358.50	83.500	0.034
VRL	17	13.91	236.50		
AIL	17	23.94	407.00	35.000	0.000
ARL	17	11.06	188.00		
VIL	17	21.53	366.00	76.000	0.017
VRL	17	13.47	229.00		
VIL	17	24.56	417.50	24.500	0.000
ARL	17	10.44	177.50		
VRL	17	21.97	373.50	68.500	0.009
ARL	17	13.03	221.50		

According to results with Bonferroni Adjustment, it was found significant difference between AIL and ARL ($U=35.000$, $z=-3.787$, $p<0.0083$, $r=0.65$), VIL and ARL ($U=24.500$, $z=-4.153$, $p<0.0083$, $r=0.71$). Lastly, Wilcoxon Signed Rank Test was used for comparing pre-post test scores of groups (**Table 13**).

Table 13. Wilcoxon Signed Ranks Test Results

Group	Post Test-Pre Test	N	Mean Ranks	Sum of Ranks	z	P
AIL	Negative Rank	0	0.00	0.00	-3.628*	0.000
	Positive Rank	17	9	153.00		
	Ties	0	-			
VIL	Negative Rank	0	0.00	0.00	-3.625*	0.000
	Positive Rank	17	9	153.00		
	Ties	0	-			
VRL	Negative Rank	0	0.00	0.00	-3.634*	0.000
	Positive Rank	17	9	153.00		
	Ties	0	-			
ARL	Negative Rank	3	8.00	24.00	-2.062*	0.039
	Positive Rank	12	8.00	96.00		
	Ties	2	-			

*Based on negative ranks

As shown in the **Table 13**, there was significant difference between pre-test and post test scores after instructions of the Authentic Inquiry-based Laboratory ($z=3.628$, $p<0.05$, $r=0.62$), Virtual Inquiry-based Laboratory ($z=3.625$, $p<0.05$, $r=0.62$), Virtual Recipe-like Laboratory ($z=3.634$, $p<0.05$, $r=0.62$), Authentic Recipe-like Laboratory ($z=2.062$, $p<0.05$, $r=0.35$).

To evaluate the pre-service science teachers' understanding and conceptual change, their responses to each item were analysed and the percentage of the pre-service science teachers' choices for each option was calculated. Alternative conceptions determined in this study are presented in the Appendix. According to the findings, the pre-service science teachers had 83 alternative conceptions (Chemical kinetics: 18, chemical equilibrium: 7, thermochemistry: 9, acids and bases: 37 and electrochemistry: 12). These alternative conceptions were classified under subheadings and these subheadings were reaction rate, concentration effect, reaction rate constant, surface area effect, catalyst effect, reaction mechanism, temperature effect, collision theory; Le Chatelier's Principle, temperature effect, equilibrium constant; endothermic reactions, reaction enthalpy, bond energy, exothermic reactions, neutralization heat; titration, strength of acids and bases, indicators, neutralization, equivalence point, acid-base equilibrium, buffer solutions, cell potential, metal electrodes, galvanization and plating, anode-cathode before the instruction. The frequency of each alternative conception changed different ratios after the instruction. The results indicated that the frequencies of alternative conceptions identified in the pre-test, decreased in the post-test. Decreasing of frequencies of alternative conceptions was arranged in the order Authentic Inquiry-based Laboratory (AIL), Virtual Inquiry-based Laboratory (VIL), Virtual Recipe-like Laboratory (VRL) and Authentic Recipe-like Laboratory (ARL) except for chemical kinetics topics. This result may be because the pre-service science teachers in ARL were instructed the first topic in their current learning environment based on a traditional recipe-like laboratory approach; the other groups were trained in different learning environments for the first time. In view of this, it was thought that the pre-service science teachers in VRL, VIL and AIL focused on their new learning environments rather than the learning issue. For this reason, their alternative conceptions could not be remedied as was required.

According to the results, the influence of instructional treatment on understanding depends on whether the learning environment was authentic or virtual. Therefore, the influence of instructional treatment on understanding is different for authentic and virtual environments. For example, while the instructional treatment of AIL and VIL was a guided-inquiry-based learning approach; AIL had higher mean score than VIL in the post-GCCT. Similarly, while the instructional treatment of VRL and ARL was the traditional recipe-like approach, VRL had higher mean score than ARL in the post-GCCT. It was also found that mean scores of groups were arranged in the order AIL, VIL, VRL and ARL. These results indicated that the pre-service science teachers' conceptual understanding was better for the authentic inquiry-based laboratory environment than for the virtual inquiry-based laboratory environment and virtual recipe-like experiment than for the authentic recipe-like experiment. In addition, the guided-inquiry-based learning approach was more effective than the traditional recipe-like approach in promoting the pre-service science teachers' conceptual understanding. The pre-service science teachers achieved knowledge themselves using their high level thinking skills such as formulating a hypothesis, planning an experiment, interpreting and inquiring findings in the inquiry based learning environment. In addition, the pre-service science teachers only followed their recipes for conducting an experiment, they did not achieve new knowledge themselves and they only proved it in the traditional recipe-like environment. In the literature, research has compared the inquiry-based learning approach with the traditional approach and they agree with the results of the present study (e.g. Akben, 2015; Almuntasheri, Gillies, & Wright, 2016; Buckner & Kim, 2014; Franklin et al., 2015; Hemraj-Benny & Ian Beckford, 2014; Hsiao et al., 2017; Kaya & Yilmaz, 2016; Ozkan & Bumen, 2014; Ramnarain, 2014; Yetişir, 2016). Although the learning environments of VIL and VRL were virtual laboratories, VIL had no significantly higher mean score than VRL in post-GCCT. This situation can be explained as the effect of the guided-inquiry-based approach. In addition, the pre-service science teachers in VIL had an opportunity to communicate with their instructor during the instruction by GIBVL software. These properties make them more active. In addition, feedback gave them a chance to correct their mistakes. These situations can be effective in the understanding of the pre-service science teachers. In previous research, it was underlined that the interactive virtual laboratory provided an effective action-reaction process and learning became more meaningful in this way (Ozdener, 2005; Tatli, 2011; Trindade et al., 2002).

Although instructional treatments of VRL and ARL were based on a traditional recipe-like approach, VRL had no significantly higher mean score than ARL in the post-GCCT. This situation can be explained by the effects of the virtual environment. The pre-service science teachers got used to conducting an experiment based on the traditional recipe-like approach because virtual experiments were different and interesting for the pre-service science teachers in VRL. Therefore, the pre-service science teachers in VRL focused more on the learning issue. Although virtual environments had different and interesting content and contributed to conceptual understanding by providing different learning environment experience, previous research that compared a real laboratory with a virtual laboratory had different results. Some of this research indicated that virtual laboratory instruction was more effective than traditional laboratory instruction in promoting conceptual understanding (Bakar & Zaman 2007; Bozkurt, 2008; Kennepohl, 2001; Tatli, 2011; Tuysuz, 2010). On the other hand, Bernard et al. (2004) and Cavanaugh et al. (2004) found that there was no difference between the contributions of virtual and traditional laboratories to students' achievement. In addition, some of the virtual laboratory research emphasized that virtual laboratories had some limitations, such as interaction with laboratory materials and chemicals (Bucos et al., 2008), improving skills in this way (Carnevale, 2003; Diker, 2011).

CONCLUSIONS

The aim of the present study was to investigate the effect of four different learning environments, Authentic Inquiry-based Laboratory, Virtual Inquiry-based Laboratory, Authentic Recipe-like Laboratory and Virtual Recipe-like Laboratory, on the pre-service science teachers' understanding of chemistry concepts. According to the results, the Authentic Inquiry-based Laboratory was the most effective learning environment for the pre-service science teachers' understanding and remedying of alternative conceptions except for chemical kinetics and the least effective one was the authentic recipe-like laboratory. For the instructional treatment, the guided-inquiry-based approach was more effective than the traditional recipe-like approach both authentic and virtual environments. For the learning environment, while the authentic environment was more beneficial than the virtual environment when it was supported by guided-inquiry-based learning; the virtual environment was more effective than the authentic environment when it was based on the traditional recipe-like approach. However, the virtual environment had the best effect when it was supported by guided-inquiry-based learning.

In the light of results of research, it was concluded that guided-inquiry-based learning can be used in both authentic and virtual laboratories for improving conceptual understanding of chemistry concepts. In brief, if the learning environment is supported by the appropriate learning approach, it will be effective. A virtual laboratory can be preferred as an alternative to the authentic laboratory when dangerous, expensive or long experiments are conducted or there is no laboratory in the school. However, it was suggested that if virtual laboratory is used, it should be supported by active learning approach such as guided-inquiry-based learning. In addition, because students could not use their psychomotor skills in a virtual laboratory as mentioned by previous research, the authentic laboratory should be preferred by instructors.

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APPENDIX

Alternative conceptions were determined in this research.

			AIL		VIL		VRL		ARL	
		Alternative conception	**Pre Test (f)**	**Post Test (f)**	**Pre Test (f)**	**Post Test (f)**	**Pre Test (f)**	**Post Test (f)**	**Pre Test (f)**	**Post Test (f)**
CHEMICAL KINETICS	Reaction rate	Reaction rate is the process of conversion from reactants to products	10	9	6	4	4	5	2	2
		The reaction rate indicates how much time a reaction takes to complete.	2	3	5	6	4	6	5	6
	Concentration Effect	When the concentration of reactants decreases, reaction rate increases.	8	5	5	3	3	5	1	6
		As concentration increases, the number of particles per unit volume also increases; as a result, the particles' motion area decreases and their collision becomes difficult.	7	7	4	4	8	7	9	2
	Reaction rate constant	Reaction rate constant depends on the concentration of reactants.	4	5	7	7	7	4	10	7
		When concentration increases, effective collision increases and thus reaction rate constant increases.	4	5	7	6	7	4	10	8
	Surface Effect	When surface area increases, the reaction rate decreases for equal amounts of the same substances.	9	8	11	7	10	8	14	6
		When surface area increases, the molecules' kinetic energy decreases for equal amounts of the same substances because the volume of reaction environment decreases.	5	6	4	3	4	2	5	4
	Catalyst Effect	Catalysts do not affect reaction.	11	11	9	6	13	12	11	8
		Catalysts do not affect reaction rate because they do not run out in the reaction.	10	9	9	7	7	9	11	7
		Catalysts make possible the reaction to reach the equivalence point, fast.	2	2	4	5	6	5	5	1
		Catalysts provide more yielding reactions.	9	8	4	3	6	5	5	11
	Reaction mechanism	The reaction rate constant of the fast step is greater than the slow step's reaction rate constant in a reaction that has two-steps	10	9	10	8	13	13	13	9
		The reaction rate constant of the slow step is greater than the fast step's reaction rate constant in a reaction which has two-steps because the reaction rate depends on the slow step.	8	10	7	6	11	10	14	8
	Temperature Effect	When the temperature increases, the reaction rate increases in endothermic reactions and the reaction rate decreases in exothermic reactions.	12	14	9	10	14	12	15	8
		The effect of temperature on reaction rate is in an enhancer direction in endothermic reactions and in a detractive direction in exothermic reactions.	10	13	10	13	15	14	13	9
		When the temperature increases, the reaction rate increases very much in the endothermic reaction but it increases at first but later decreases in the exothermic reaction.	8	10	6	6	9	10	9	6
	Collision Theory	Each atom in a molecule should come into a collision with any other atom in the other molecule for an effective collision.	7	5	9	9	11	11	7	8
CHEMICAL EQUILIBRIUM	Le Chatelier's Principle	If an intervention is made to a reaction that is at equilibrium at a constant temperature, the equilibrium is re-established by the concentration of the products and the reactants which are equalled.	7	8	4	3	6	7	4	4
		If an intervention is made to a reaction that is at equilibrium at a constant temperature, the equilibrium is re-established because some substances run out in the reaction.	5	2	5	3	4	3	1	8
	Temperature Effect	If the temperature increases, the reaction always favours the product in exothermic equilibrium reactions.	7	3	7	1	4	0	4	3
	Equilibrium Constant	When the temperature increases, the equilibrium constant decreases in endothermic reactions.	4	1	6	6	4	4	4	3
		When the temperature increases, the equilibrium constant is not affected.	8	4	6	7	8	6	5	8
		When the temperature increases, the equilibrium constant increases only in endothermic reactions	8	2	8	1	7	2	3	5
		When the temperature increases, the equilibrium constant decreases only in exothermic reactions	2	5	3	4	5	4	8	0

			AIL		VIL		VRL		ARL	
		Alternative conception	**Pre Test (f)**	**Post Test (f)**	**Pre Test (f)**	**Post Test (f)**	**Pre Test (f)**	**Post Test (f)**	**Pre Test (f)**	**Post Test (f)**
THERMOCHEMISTRY	Endothermic Reactions	The activation energy for the reverse reaction is greater than the activation energy for the forward reaction in endothermic equilibrium reactions.	8	9	8	3	5	6	8	7
		An endothermic equilibrium reaction reaches activation energy faster because it gets energy from outside.	4	3	5	3	4	3	4	3
	Reaction Enthalpy	Reaction enthalpy is the temperature difference between the system and the environment.	7	4	5	3	6	3	6	6
		Reaction enthalpy is the temperature difference between before and after the reaction.	7	4	8	5	3	5	8	1
		Reaction enthalpy is the temperature difference stored in the products' and reactants' chemical bonds.	6	5	7	3	10	7	6	10
	Bond Energy	The energy required to break the bonds in the reactants' molecules is greater than the energy required for the formation of bonds in the products' molecules in exothermic reactions.	5	7	7	7	3	10	8	9
		The energy stored in chemical bonds is released by reactions.	3	2	5	2	6	2	8	0
	Exothermic Reactions	The energy stored in products' bonds is less than the energy stored in reactants' bonds in exothermic reactions.	2	6	4	9	5	8	3	5
	Neutralization Heat	A reaction that occurs between an acid solution and a base solution has greater heat of neutralization than a reaction that occurs between a solid base and an acid solution.	7	3	4	4	6	2	6	5
ACIDS AND BASES	Titration	pH is 7 at the equivalence point in the titration of strong base and weak acid	7	6	9	5	6	4	7	6
		Weak bases cannot be titrated with weak acids.	6	8	6	7	8	10	5	7
		pH is always 7 at the equivalence point in a titration in which a strong base is a titrant and a weak acid is an analyte.	6	5	7	5	6	3	5	9
		pH is always between 3 and7 at the equivalence point in a titration in which a strong base is a titrant and a weak acid is an analyte.	5	5	5	4	5	8	9	8
		Weak acids/weak bases cannot be titrated.	4	2	6	3	9	4	8	7
		Any indicator changes colour at the turning point in a titration.	4	2	4	2	8	3	7	2
		Titration depends on only the neutralization of acid and base, the indicator is not important in the titration.	8	0	4	0	3	0	3	1
		Acid and base must be at an equal volume for titration.	3	1	5	2	5	0	5	2
	Strength of acids and bases	pH is the measure of acidity strength.	11	4	15	6	14	6	14	5
		The strength of acids is determined by a pH meter.	8	7	14	7	9	7	8	8
		The strength of acids is determined by the concentration of solution.	4	3	0	0	2	0	5	2
		If pH decreases, the strength of acids will increase.	8	5	12	5	7	7	7	9
		pH of strong bases is close to 14.	8	1	6	2	11	6	8	7
		If pH is close to 1, the strength of acids increases.	12	7	12	4	12	6	11	6
	Indicators	Indicators increase the reaction rate.	2	2	6	6	5	3	9	6
		Indicators decrease the reaction rate.	11	1	10	0	11	3	6	2
		Indicators provide an alternative way for the reaction to happen that has a lower activation energy.	6	3	9	3	7	1	11	3
	Neutralization	If an acid solution and a base solution are mixed in any amount, the pH is always 7.	6	3	6	6	5	7	7	12
		Neutralization reaction does not occur between weak acids and weak bases.	4	5	4	2	3	8	8	5
		If an acid solution at equal volume and concentration is added to a base solution, salt and water are always formed.	7	4	11	5	9	8	11	6
		If an equal amount of acid and base react, pH is always 7.	10	1	5	6	4	3	1	4
		If an acid solution at equal volume and concentration is added to a base solution, acid gives its H^+ to base's OH^- and water is formed.	6	5	4	3	7	7	11	8
		Neutralization occurs between only a strong acid and a strong base.	1	1	4	0	4	1	4	2
		If a base solution at any amount is added to an acid solution, the concentration of H_3O^+ is greater than the concentration of OH^- in that solution.	6	13	3	0	5	11	4	8
		If a base solution of any amount is added to an acid solution, the concentration of H_3O^+ is equal to the concentration of OH^- in solution.	5	1	4	3	2	5	0	2

			AIL		VIL		VRL		ARL	
		Alternative conception	**Pre Test (f)**	**Post Test (f)**	**Pre Test (f)**	**Post Test (f)**	**Pre Test (f)**	**Post Test (f)**	**Pre Test (f)**	**Post Test (f)**
ACIDS AND BASES	Equivalence point	pH is always 7 at the equivalence point.	11	2	14	7	13	1	14	6
		Solutions are always neutral at the equivalence point.	10	2	11	7	8	1	10	5
		pH is always 7 at the equivalence point because neutralization occurs fully.	6	6	8	5	6	3	4	3
	Acid-Base Equilibrium	If a base is added to an acid solution at equilibrium, the reaction favours the products.	6	7	5	4	8	6	13	7
		If a base is added to an acid solution at equilibrium, the reaction equilibrium does not change.	4	5	7	6	1	6	1	8
	Buffer Solution	If acid/base is added to buffer, the solution's pH is fixed at 7.	7	2	6	3	9	0	10	3
		Acid and its conjugate base should neutralize each other in buffers.	9	8	5	10	11	10	10	11
		If the acid component of the buffer is not strong, the buffer does not resist pH change.	4	3	5	1	3	1	1	1
		If a little amount of strong base is added to a buffer, the strong base and base component of buffer combine and pH gets closer to 14.	13	1	8	2	12	6	9	8
		If a little amount of strong base is added to buffer, the base component of the buffer becomes a proton receiver.	4	2	4	7	3	5	6	3
		If a little amount of strong base is added to buffer, the base component of buffer takes a proton from the acid component of the buffer and it fixes [conjugate base]/ [conjugate acid]	3	4	5	9	4	4	8	6
		If acid/base is added to a buffer, the pH remains fixed at 7 because buffers neutralize acids and bases.	9	2	7	4	9	1	11	6
ELECTROCHEMISTRY	Cell Potential	The potential of an electrochemical cell is independent of the concentration of electrolyte in the half-cells.	8	1	9	2	6	2	8	3
		When electrolyte concentration increases, ion concentration and electron movement increase. Therefore, cell potential increases.	5	6	6	10	8	8	4	10
	Metal electrodes	High reactive metals reduce, low reactive metals oxidize.	10	9	10	9	11	7	12	7
		If metals' activity is high, their reduction potential is high but their oxidation potential is low.	2	5	6	5	7	4	11	4
	Galvanization and plating	Galvanization depends on the principle of electrolysis.	3	4	5	3	4	8	9	4
		In galvanization of iron with zinc, it must be energized for reduction of the iron electrode at the anode and oxidation of the zinc electrode at the cathode.	8	3	5	2	7	0	6	10
		In galvanization of iron with zinc, during the process of reducing the iron electrode at the cathode and oxidizing the zinc electrode at the anode, energy is released.	5	6	6	9	6	4	1	2
		In the process of covering a copper plate with tin, whose oxidation potential is greater than copper, tin is the positive and copper is the negative pole.	11	4	12	4	9	3	7	9
		In the process of covering a copper plate with tin, whose oxidation potential is greater than copper, electrons which occur after the oxidation of tin at the anode go to copper at the cathode and they lead copper to be reduced.	6	9	8	12	6	11	10	7
		In the process of covering a copper plate with tin, whose oxidation potential is greater than copper, electrons that occur after the oxidation of tin at the cathode go to copper at the anode and they lead copper to be reduced.	4	2	8	12	5	1	3	4
	Anodes and Cathodes	When the number of electrodes increases, reduction potential increases.	4	0	5	0	3	1	6	2
		The anode is positively charged and the cathode is negatively charged in an electrochemical cell.	4	0	4	1	2	0	2	0

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An Analysis of Linguistic Features of the Multiplication Tables and the Language of Multiplication

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ABSTRACT

This study analyses the linguistic features of Korean language in learning multiplication. Ancient Korean multiplication tables, Gugudan, as well as mathematics textbooks and teacher's guides from South Korea were examined for the instruction of multiplication in second grade. Our findings highlight the uniqueness of the grammatical features of numbers, the syntax of multiplication tables, the simplicity of language of multiplication in Korean language, and also the complexities and ambiguities in English language. We believe that, by examining the specific language of a topic, we will help to identify how language and culture tools shape the understanding of students' mathematical development. Although this study is based on Korean context, the method and findings will shed light on other East Asian languages, and will add value to the research on international comparative studies.

Keywords: cultural artefacts, Korean language, linguistic features, multiplication tables

INTRODUCTION

Hong Kong, Japan, South Korea and Singapore have maintained their lead in international league tables of mathematics achievement such as TIMSS and PISA. Numerous comparative studies have been undertaken in search of the best East Asian practices and factors that have contributed to high student achievement; researchers have argued that one of the major factors behind the superior performance in cross-national studies is based on the underlying culture (e.g. Leung, 2001, 2002, 2006). One major element of culture is language, and Leung (1989) believed that there are characteristics in the Chinese language which might have contributed to Chinese students' superior performance in mathematics achievement. The abstract nature of mathematics content and the use of Arabic numerals may be universal, but the system of numbers and the expression of mathematical ideas vary across languages. The clarity with which the naming of numbers reflects the logic behind the base-ten number system varies considerably across cultures. Besides the number words, the *Lexicon Project* used lexicons as tools to integrate, enhance and advance comparative classroom research, and to identify both similarities and differences in the pedagogical principles and distinctions encrypted in different lexicons (Clarke, 2013). Yet, lexical ambiguities do not fully account for the variations of linguistic ambiguities that students face in mathematics. Schleppegrell (2007) discussed the complexity of mathematical language and linguistic challenges in mathematics learning, and highlighted the need to expand our understanding of language issues in mathematics beyond the focus on vocabulary or specified terminology.

Studies on the understanding of possible linguistics influences on students' early learning of school mathematics have been mainly confined to the computational topics of addition and subtraction. Limited research has been done regarding the language instruction of multiplication (e.g. Anghileri, 1991), especially the acquisition of multiplication facts. Formal instruction on multiplication generally starts in the second year of elementary school after addition and subtraction have been taught. A good understanding of multiplication is fundamental in elementary school mathematics as it plays a vital role in a student's development of more advanced mathematical concepts in multiplicative conceptual fields, such as ratio, rate, fraction, rational number, dimensional analysis and other functional relations (Confrey, 1994; Vergnaud, 1983, 1988). Stephens, Ellis, Blanton, and Brizuela (2017)

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Contribution of this paper to the literature

- This study examines the cultural and language aspects of learning multiplication in South Korea. Dual number systems, ancient multiplication tables and school textbooks were examined based on a linguistic approach, where distinguishable characteristics have been identified.
- The use of classifiers, the absence of plural marking, passive voice and other language features in Korean, make the language of multiplication, as well as the problem situations, easier to understand and comprehend.
- We believe the study of the functionality of the natural languages in mathematics learning, and the possible language difficulties facing learners require more attention.

pointed out that much instructional time in elementary mathematics is devoted to developing fluency with multiplication, including learning multiplication facts.

From the language perspective, the way we read multiplication tables such as 3 × 4 = 12 varies in different languages. Students need to recall multiplication fact families to solve multiplication and division situated problems. For example: 'three groups of four', they need to recall the corresponding number facts for three, that is 3 times 4, in order to answer the question. It is therefore important for us to recognise the features of the numerals and lexicon in order to make the connections of the multiplication fact families and the problem situations. The set of times tables used in South Korea is known as Gugudan (구구단, means nine-nine table). It has a very long history and is deeply rooted in Korean society. Children are taught to recite Gugudan as a poem or song, where the digit names have the rhythm and analogous features of rhythmic poetry. This study is influenced by Whorf's (1956) linguistic relativity hypothesis – the structure of a language can affect the thought process of speakers of that language, which suggests that the thinking processes of the speakers of one language will differ from those of a speaker of any other language. As culture, language and cognition are intertwined in a complex manner, we believe becoming aware of the differences between languages may allow us to have a different perspective on mathematics education. Our focus is on the linguistic features of number systems, multiplication tables and the language of multiplication, which serves as the basis for our wider research study on investigating the intricate relationship between culture, language and mathematics learning.

LITERATURE REVIEW

There is increased recognition of the difficulty that many students have with mathematical language and the importance of language in learning mathematics (e.g. Morgan, Craig, Schutte, & Wagner, 2014). Researchers have started to explore the role of language in explaining the relatively superior performance of Chinese and other East Asian students in cross-national studies (see Ng & Rao, 2010). Studies showed that the linguistic features and number naming structures in Chinese language have influences on children's acquisition of mathematical concepts and later development (e.g. Miller, Kelly, & Zhou, 2005). While the clarity of Asian languages (e.g. Japanese, Korean, Thai, Burmese) has been identified to have helped to speed up initial learning of number concept and increased the understanding that occurs in classroom discourses using clear words (e.g. Fuson & Kwon, 1991; Fuson & Li, 2009), many believed the base-ten number system provides linguistic support to the learning of arithmetic operations involving the concept of place value (Fuson, 1990; Miura & Okamoto, 2003; Miura, Okamoto, Kim, Steere, & Fayol, 1993; Song & Ginsburg, 1985). In addition, Miura and Okamoto (2003) believed the use of numeral classifiers in Japanese, as part of the arithmetic story problem, may diminish ambiguity by making the referent clear. Recent study by Her, Chen and Yen (2018) on Chinese numeral classifiers showed, linguistically, classifiers highlight the inherent semantic attributes of the noun, and the linguistic system of classifiers interacts with categorization and magnitude cognition. Their findings also showed classifiers and measure words with mathematical values elicit higher neural (brain) activities for processing quantity information, which suggests that the system of classifiers is part of magnitude cognition that encodes the mathematical values (Her, 2012). The general classifier 개 (*gae*) is a Sino-Korean word associated with the Chinese character 個 (*go*). In fact, many Korean classifiers are derived from Chinese classifiers, and the grammatical use of classifiers is similar.

In the learning of multiplication, Japanese children are required to learn and recite the Kuku (means nine-nine) method of multiplication in elementary school, and it has been shown the Japanese kuku multiplication chart is an effective aid to perform arithmetic operations, and adults were found to solve multiplication problems more easily as compared to addition problems (Ito, Kubo-Kawai, & Masataka, 2011). Similar findings were also made in graduate students from China who were studying at Canada, who performed better in solving single-digit multiplication problems compared with their Canadian counterparts (LeFevre & Liu, 1997).

Studies on East Asian mathematics education place considerable focus on Chinese learners (e.g. Fan, Wong, Cai, & Li, 2004; 2015; Ho & Fuson, 1998; Miller, Kelly, & Zhou, 2005; Miller & Stigler, 1987). Nonetheless, Kwon and

Cho (2012) believed that some studies on Asian education have mistakenly assumed that mathematics education in South Korea is almost the same as that in other East Asian countries. Thus far, relatively little has been written about Korean language and mathematics learning, and limited research has been devoted to the area of mathematics content: counting in two different numbers systems (Song & Ginsburg, 1985, 1986), and addition and subtraction problems with single (Fuson & Kwon, 1992a) and multi-digit numbers (Fuson & Kwon, 1992b).

CONCEPTUAL FRAMEWORK

Research on linguistic complexity addresses the impact of lexicogrammatical structure on mathematical thinking; it is not just whether a certain concept can be expressed in a certain language, but the ease of expression of the concept: that is how the words and structures facilitate or impede expression. Introduced by Halliday, lexicogramma is a term used in Systemic Functional Linguistics (SFL). To him, grammar means lexicogrammar; that is, it includes vocabulary. The grammatical (lexicogrammatical) system is the system of what the speaker *can say*; and the lexicogrammatical system, as a whole, operations as the realization of the semantic system, which is what the speaker *can mean* (Halliday, 1978). One way of describing the relation between mathematics and languages is in terms of the linguistic notion of register, i.e. the language we speak or write varies according to the types of situation, and the theory of register is to attempt to uncover the general principles which govern this variation, in order to understand which situational factors determine which linguistic features (ibid). Halliday believed every language embodies some mathematical meanings in its semantic structure – ways of counting, measuring, classifying and so on. His linguistic notion of register and the sociolinguistic aspect of mathematical education underpins this research study. Mathematics register is the sense of meanings that belong to the language of mathematics (the mathematical use of natural language, that is: not mathematics itself), and that a language must express if it is being used for mathematical purposes. Mathematics register has specific vocabularies, and their development can be marked in various ways including: 1. Creating words out of native word or non-native word stock (such as Greek and Latin); 2. Borrowing words from another language (the method most favoured in Korea). Words like fraction (분수), algebra (대수) and geometry (기하) are borrowed from Chinese; 3. Reinterpreting existing everyday words with specific mathematics meaning. The ease with which a mathematics register develops depends, in part, on the grammatical system of the natural language. As mentioned, Chinese-based regular numbering systems have shown many advantages in early mathematics learning (Fuson & Kwon, 1991; Miller & Stigler, 1987; Miura & Okamoto, 2003). For instance, short single-syllable number words reduce the burden on working memory (see Ng & Rao, 2010); and base-ten system supports the understanding of place value and learning of addition and subtraction (e.g. Geary, Bow-Thomas, Fan, & Siegler, 1993). Barton (2009) believed that the reason some languages find certain mathematical expressions, or uses of numbers, far easier to deal with than others may be due to the varied syntactic roles of numbers in different languages, i.e. whether numbers operate as nouns, verbs or adjectives. For example, the absence of singular and plural forms of nouns in Korean and Japanese, and the way numbers operate varies in numeral classifier languages (Allan, 1977) make numbers more transparent. Classifiers are words that suffix to a numeral when counting and they are used extensively in Korean (Lee & Lee, 2009) and Japanese (Downing, 1996).

On the other hand, the linguistic challenges of the language of multiplication in English had been discussed in Anghileri (1991); in particular, the choice of wordings associated with multiplication symbols, where different interpretations are known to exist, and the ambiguity when attaching meaning to symbolic arithmetic expressions present considerable barriers to children's understanding. Additional confusion may arise with use of vocabularies in multiplication such as 'times', 'multiplied by', 'multiply by' etc. Concepts of numbers, of multiplication and division may be variously highlighted in the semantics of different languages. Research on the semantic aspect of mathematical language mainly focuses on mathematical problems (Solano-Flores, 2010), and the popular introduction for the concept of multiplication usually involves a variety of multiplicative situations that embody the operations. Greer (1992) believed that the most important classes of situations involving multiplication and division of integers are: equal groups, multiplicative comparison, Cartesian product and rectangular array (area). Watanabe (2003) used Greer's framework and found different emphases were placed in textbook series from Japan and the United States, suggesting cultural differences in terms of the teaching of multiplication.

In this section, we have discussed the mathematics register and research in language and mathematics education. Mathematics register allows us to express our mathematical understanding, ideas, and to communicate with one another. Thus, we must share the same mathematical meanings of words and expressions. We viewed Gugudan as mathematics register, which has the power to conjure a complex web of ideas that make up the mathematical concept to solve problems. It is a way of using language to express mathematical concepts and even characterize the mode of presenting multiplication operations. We considered Gugudan as a cultural artefact and the recitation of Gugudan is a sociocultural activity that represents the sediment of past learning that is effective and useful; therefore, it becomes part of the social action without any conscious planning. As long as the actions remain habitual, we seldom pause to ask about the values they serve, and do not need any justification as long as

Table 1. Linguistic Factors in Mathematics Education

	Language as System	Aspects of Investigation
Lexico-grammar (words and structures)	Vocabulary (words)	Number words, bea 배 and multiply 곱하기
	Morphology (word structures)	Nouns, numeral classifiers and plural marking
	Syntax (sentence and phrase structure – word order)	Number sentences
Semantics (meanings)	Arguments & single items	Word problems
Symbols	Degree and kind of fit between verbal expression and mathematical notation	×

we are not called to account by others or abrupt changes in the circumstances in which we act. Hence, we could like to take a linguistic approach in understanding the learning of multiplication and our research questions are:

i. What are the linguistic features of Korean numerals? How are Korean multiplication tables read?

ii. What are the lexicogrammatical and semantic features in the language of multiplication?

RESEARCH METHOD

We have adopted the document analysis as a qualitative research method for this study. We collected and reviewed several classical texts on mathematics including the *Ten Treatises of Mathematical Classics* (산경십서 算經十書), the *Nine Chapters on the Mathematical Arts* (구장산술 九章算術) and *Introduction to Mathematical Studies* (신편 산학계몽 총괄 新編算學啓蒙總括); as well as the elementary mathematics textbook series and the teacher's guide in South Korea. We extracted language data with the aspects of multiplication given in these documents, and examined the words and sentences in the mathematical text. We considered language as a system and adopted the analytical framework suggested by Halliday (1978, p.204) as shown in **Table 1** in analysing the followings documents:

(1) *Introduction to Mathematical Studies (신편 산학계몽 총괄, 新編算學啓蒙總括)*, written by Zhu Shijie (주세걸 朱世傑) in Yuan Dynasty, is one of the most influential classical mathematics books transmitted from China to Korea. It was used as the core text for the civil examinations during the Choson Dynasty. The book contains the multiplication tables, Gugudan (see **Figure 2**), that are still used today in South Korea. It was lost and only appeared again in the nineteenth century in China, and it did not seem to have any impact on the Chinese mathematical development (Chemla, 2008). We consider Gugudan as a mathematics register, and a cultural tool for mental calculation which has been passed down from generation to generation.

(2) *Mathematics (수학)* is the elementary mathematics textbook series developed and published by the Ministry of Education, and used in elementary schools throughout South Korea. Each grade level contains two textbooks and two exercises books. Our analysis was based on the 2016 version developed for the 2009 mathematics curriculum, which included Mathematics 2.1 (수학 2.1) and Mathematics 2.2 (수학 2.2). According to the teachers' guide in Chapter 6, Book 2.1, ten lessons at the end of the first semester are dedicated to the understanding of simple multiplication concepts in daily life; and in Chapter 2, Book 2.2, twelve lessons in the second semester are dedicated to the teaching of multiplication facts and the operation of single digit multiplication. Within the twelve lessons, eight are allocated to the teaching of multiplication facts, and the rest of the lessons focus on identifying patterns of multiplication. The concept of division is taught starting from third grade.

Our analysis consisted of three stages: First, we examined the two Korean number systems and their number words from the linguistic perspective – the morphology and syntactic (or grammatical) category of Korean numerals, i.e. whether numbers operate as nouns, verbs or adjectives. These categories generally form a larger phrasal category having a distinctive structure, i.e. from a noun to noun phrase, which can act as a complete subject, object, etc. in a sentence, e.g. "three children", "four cookies". And since Korean is a numeral classifier language, we analysed the structural features of the number construction, i.e. noun-numeral-classifier, 어린이 (child) 3 명and 쿠키 (cookie) 4 개, and the usages and conditions for selecting classifiers. Second, we analysed the morphology and syntax of number sentences in the multiplication tables, written in Chinese characters and Hangul (한글), the Korean alphabet. This provided us insight into how these sentences are being used when students make sense of abstract concepts. Third, we studied the content and the organization of the second grade textbooks and teachers' guides along with specific mathematical ideas on the concept of multiplication and its operation. We identified certain quantifiable characteristics, including the number of suggested lessons where multiplication concepts and

Table 2. Korean Numerals

	Sino-Korean numerals	Pronunciations	Native numerals	Pronunciations
1	일	*il*	하나	*hana*
2	이	*i*	둘	*dul*
3	삼	*sam*	셋	*set*
4	사	*sa*	넷	*net*
5	오	*o*	다섯	*daseot*
6	육	*yuk*	여섯	*yeoseot*
7	칠	*chil*	일곱	*ilgop*
8	팔	*pal*	여덟	*yeodeol*
9	구	*gu*	아홉	*ahop*
10	십	*sip*	열	*yeol*
11	십일	*sib-il*	열 하나	*yeol-hana*
12	십이	*sib-i*	열 둘	*yeol-dul*
…				
20	이십	*i-sip*	스물	*seumul*
30	삼십	*sam-sip*	서른	*seoreun*
40	사십	*sa-sip*	마흔	*maheun*
50	오십	*o-sip*	쉰	*swin*
60	육십	*yuk-sip*	예순	*yesun*
70	칠십	*chil-sip*	일흔	*ilheun*
80	팔십	*pal-sip*	여든	*yeodeun*
90	구십	*gu-sip*	아흔	*aheun*
100	백	*baek*	-	-

ideas are introduced and developed. We were particularly interested in language used in the teaching and learning of multiplication. We examined the problem situations in a variety of contexts in which multiplication operations can be applied, since it is believed that the distinctions between classes of multiplication situations are important pedagogically and provide an analytical framework useful for guiding research (Greer, 1992). We investigated the mathematical terms and the semantic features in the word problems. We also compared the verbal expression of mathematical notations ×, and the syntax of the multiplication sentences in Korean and English languages. We explored the linguistic features of the language of multiplication and the possible effect on the understanding of the properties and relationships of the operation. We also tried to point out some of the complexities and ambiguities in English, and identified some common difficulties that may be experienced by English-speaking students.

FINDINGS: KOREAN NUMBER SYTEMS AND THE MULTIPLICATION TABLES

Korean Number Systems and Number Words

There are two systems of numbers in Korea (see **Table 2**): one of Chinese origin, namely the Sino-Korean, usually used for cardinal numbers, large numbers and calculation. Similar to the original system, the number formation in Sino-Korea is regular and apparent when compared with English, which explicitly corresponds to the base-ten composition of the number. Sino-Korean number words above 10 are generated by consistent rules, and the literal translation of 'eleven' and 'twelve' into Korean corresponds to '십일' ten-one and '십이' ten-two, indicating their composition of the decade value and unit value. The number words are also regular for the decade words such '이십' two-ten, '삼십' three-ten for twenty and thirty; multiplies of ten are simple juxtapositions. Sino-Korean numerals start from one and go all the way to one hundred million '억 (億)' and to trillion '조 (兆)'. The other number system is native in origin, the native numerals are also structured as '열 하나' ten-one, '열 둘' ten-two and so on. Both are base-ten systems, but one can only count to 99 '아흔 아홉' using native numerals; Past that number one must count by making use of Sino-Korean numerals. Hence, native numerals are usually used for small numbers such as counting and telling one's own or other people's age.

As can be seen from **Table 2**, the native numerals are less regular than Sino-Korean with one to two syllables, yet they are more regular when compared with English. According to Lee & Ramsey (2000), Sino-Korean is ordinarily preferred when making mathematical calculation, as in 3 + 3 = 6, read as 삼 (더하기) 삼 (은) 육 (*sam te-haki sam un yuk)*. There are restrictions and considerations to bear in mind when choosing between native Korean and Sino-Korean numerals and Korean students need to use both number systems in dealing with school mathematics and their daily life. For instance, the answer to the question 3 + 3 = 6, where all the values are purely numerical, would be expressed in Sino-Korean 삼 (*sam*) and 육 (*yuk*). But if you replace the numerical 3 with a question about the total number of apples, the answer to the question would no longer 육 (*yuk*) but 여섯 (*yeoseot*), a native Korean number. Also, if you want to say "the double of three is six" – 3의 2배는 6 입니다, it is spoken where 삼 (*sam*) and 육 (*yuk*) are Sino-Korean numbers but 두 (*dul*), a native Korean number, is used instead of 이 (*i*) (which will be discussed in later section). In addition, numbers written in Arabic numerals are regularly read as Sino-Korea. The Sino-Korean number names embedded with the base-ten principle that underlies the structure of Arabic numerals is a feature of the representational system, not a fundamental mathematics fact; it is, however, incorporated into many of the algorithms student learn for performing arithmetic, thus it is a powerful concept in their mathematical development.

The Morphology of Korean Numerals

Nouns

In the Korean language, the grammatical functions are expressed by attaching case particles or other various role-marking particles, which indicate the roles of noun phases with respect to the event described by the verb or the state of condition expressed by the adjectives. Therefore, Korean numerals are similar enough to be classed together with nouns and pronouns (Lee & Ramsey, 2000). Nouns in Korean are normally not marked for number (i.e. singular or plural). The plural making 들 –*tul* in Korean is said to occur mainly with human nouns, less frequently with non-human animate nouns and far less frequently with inanimate noun (Song, 2005). In English, on the other hand, it is absolutely necessary to mark nouns for number, and to indicate explicitly (that is, by means of –*s* or –*es*) whether one is talking about one person, or two or more persons, a bus or two or more buses, and so on. When nouns in Korean are preceded by plural numerals such as '삼' three, plural marking is regarded as completely redundant and not used at all.

Classifiers

In Korean grammars, there are types of nouns that do not appear independently in the sentence, and one type of bound noun is the classifier. It is chosen strictly by the type of noun being counted because noun and classifier must always be in agreement. In English, numerals are freely used in conjunction with nouns alone to indicate the number or amount of entities being spoken of. For example, one can say two books or three people. But in Korean, one must say '책 두 권' (book + 2-bound volumes), and '사람 세 명' (people + three-person); the classifier (CL) 권 (*kwon*) must be used in order to express what is being counted, which is characteristics of bounded volumes such as a book. Nouns must always co-exist with an appropriate classifier for the purpose of counting. For example, it is grammatically wrong to use '권 (*kwon*)' instead of '명 (*myeong*)' to express the number of people. There are a fair number of classifiers in Korean, which can be categorised into several types according to semantic concepts such as animacy, shape, and function (Adams & Conklin, 1973). The use of classifiers is illustrated in **Figure 1**. This multiplicative situation is the most important class known as "equal groups", in which the number of objects within each group is the same, and normally constitutes a student's earliest encounter with multiplication (Greer, 1992). The multiplicand is the set of the groups, the multiplier indicates how many groups there are, and the product is a collection of equal groups. This word problem in Korean would be translated into English as:

Figure 1. Multiplication of 2, the equal groups situation

There are two beetles (*mali*) in each frame (*gae*).
How many beetles (*mali*) in 1 frame (*gae*)?
How many beetles (*mali*) in 2 frames (*gae*)?
How many beetles (*mali*) in 5 frames (*gae*)?

In this situation, the number of beetles in each frame is the multiplicand and the number of frames is the multiplier. The number construction is Noun-Number-Classifier (CL), 사슴벌레 2 마리 (beetle 2 CL.animal) and 액자 1 개 (frame 1 CL.piece). The two numbers play clearly different roles with different classifiers; in the case of animals, the prototypical numerical classifier is 마리 (*mali*), and 개 (*gae*) belongs to the numerical classifiers for inanimate entities. According to the teacher's guide, a classifier is required in answering these word problems, i.e. *n* 마리입니다 (*n* CL.animal).

multiplicand	×	multiplier	=	product	
2	×	1	=	2	마리입니다
2	×	2	=	4	마리입니다
2	×	5	=	10	마리입니다

Table 3. Korean Numeral Classifiers

Sematic class	Numeral classifier	Original meeting	Gloss	Examples
Human	명(*myeong*)	name	CL.name	학생은 몇 **명**입니까?
				사람은 몇 **명**입니까?
Animals	마리(*mali*)	head	CL.animal	나비는 몇 **마리**입니까?
Plants	송이 (*songi*)	blossom	CL.blossom	꽃은 몇 **송이**입니까?
Inanimate entities	개(*gae*)	piece	CL.piece	토마토는 모두 몇 **개**일까요?
				음료수는 몇 **개**인지 곱셈식으로 알아보시오.

Korean students are always taught, and repeatedly insisted upon, to write multiplicand before multiplier; even after the commutative law has been introduced, the order of the multiplication sentence stays the same. As we can see, when the multiplier is increased by 1 개 (*gae*), the product is increased by the multiplicand 2 마리 (*mali*), i.e. it is clear that the number of 마리 (*mali*) increased by adding each 개 (*gae*), and the product always has the same classifier as the multiplicand. Kaput (1985, p.13) asserts that "elementary mathematics of school should not be, as tacitly assumed, exclusively the mathematics of number with applications regarded as separate, but rather should begin with the mathematics of quantity, so that the mathematics and its application are of a piece from the very beginning". This was elaborated upon by Greer (1992, p. 284): "thus attention should be paid not simply to the numbers in a problem but also to the referents of the numbers". Miura and Okamoto (2003) believe the use of numeral classifiers in Japanese makes the referent clear, and provides a stronger visual representation of what the problem is asking. When numbers refer to objects in a situation, for example 두 마리 (two-animal), and 다섯 개 (five-piece), they make much more sense to students than when they do not refer to anything at all. Classifiers which are categorical in natural, when suffixed to numerals, provide students with a meaning for the numbers. Hence, students would have a better sense of different numbers in the multiplicative situation and what they need to do in order to solve the word problem. Classifiers are used extensively throughout the textbooks, particularly when solving word problems. Wherever objects are counted, an appropriate classifier must be selected according to its semantic property; i.e. the classifiers have a paradigmatic relationship. The use of correct classifiers is considered to be related to student's cognitive development based on the semantic features of objects (e.g. Lee, 1997; Uchida & Imai, 1996). Students must be aware which classifier goes with which noun; examples of different classifiers used in multiplication word problems are shown in **Table 3**.

As we have mentioned earlier, the difference between singular and plural is not reflected in the noun or in any morphological form. Whether one says 'one butterfly' 한 마리 (1-CL.animal) or 'ten butterflies' 열 마리 (10-CL.animal) or we say 'one rose' 한 송이 (1-CL.blossom) or 'ten roses' 열 송이 (10-CL.blossom), the form of the noun does not change as there is no plural marking for classifiers.

The Ancient Multiplication Tables

3 × 4 = 12 can be read as three multiplied by four is twelve, or three times four is twelve, or four threes are twelve in English. It can be read as さんし じゅうに (*sann shi jyuni*) in Japanese, 三四一十二 (*saam sei yat sahp yih*) in Chinese, and 삼 사 십이 (*sam sa sip il*) in Korean. The pronunciations of these East Asian languages sound very similar, and these sentences can be literally translated as "three four ten-two", which is a sequence of numbers without any indication of the multiplication operation.

Gugudan was first written in Chinese characters (see **Figure 2**) using the Sino-Korean number system. In the Hangul version used today in Korea, only number words and topic particles (TOPIC)은/는 (*un/ nun*) are included, and they are short single-syllable words that can be chanted like a children's rhyme There is no multiplication symbol nor any indication of the arithmetic operation. Gugudan consists of short sentences of number sequences. When read (see **Table 4**), for example, 2×1=2 is 이 일은 이 (*i il un i*), two-one-TOPIC-two, which is the same as the multiplication sentence in Arabic numerals, only without the symbols. 은/는 is the topic particle that is attached to a noun to indicate the subject of the sentence. According to Song (2005, pp. 145), "it is generally well understood to have a topic marking function, but in reality this topic marking function alone does not explain everything it does in natural discourse". This topic particle is used mainly in multiplication tables of smaller numbers, such as 2 and 3, and becomes obsolete when the product is larger than ten, i.e. more than one single syllable. Therefore, we may assume that the use of a topic particle here is due to a phonological reason. Gugudan is both a spoken and written

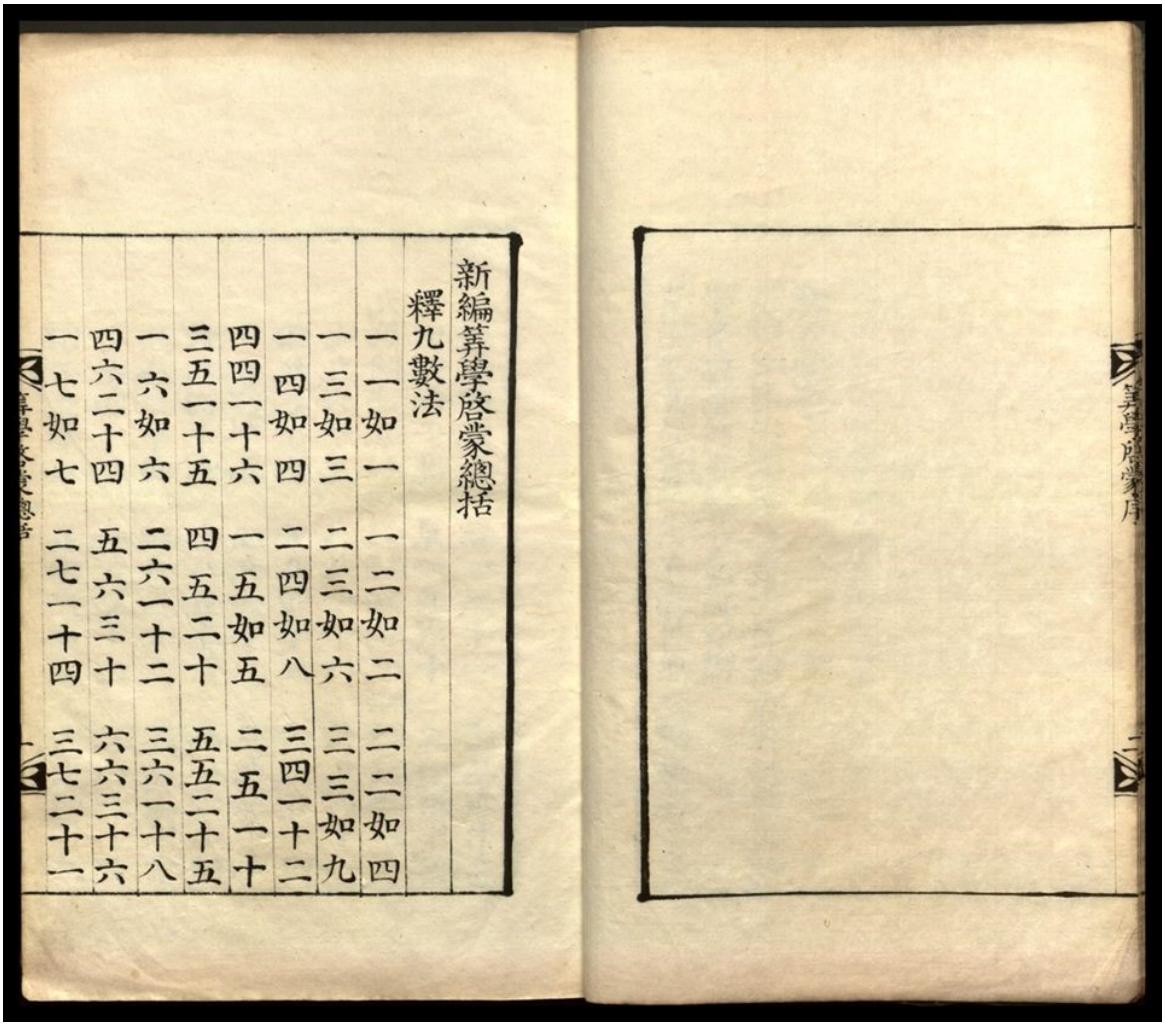

新編筭學啓蒙總括
釋九數法
一一如一 一二如二 二二如四
一三如三 二三如六 三三如九
一四如四 二四如八 三四一十二
四四一十六 一五如五 二五一十
三五一十五 四五二十 五五二十五
一六如六 二六一十二 三六一十八
四六二十四 五六三十 六六三十六
一七如七 二七一十四 三七二十一

Figure 2a. Introduction to Mathematical Studies 신편산학계몽총괄

language; it is a way of expressing multiplication in the Korean language. It is a set of codes which is embedded in the symbolic construal of language, and only those with this knowledge would be able to decode its use, i.e. it is a cultural artefact and mathematical tool that is only shared by the Korean society. In contrast, there are several ways to read the multiplication tables in English, for examples "One two is two; two twos are four …" noticed that the sequence of the number is the reverse of the multiplication sentences in the table. Another way of reading the table is "two times one is one; two times two is four…" There is no standard way of reading the set of tables, the choice depends on the users. Therefore, the simplicity and regularity of the Sino-Korea number words and the syntax of Gugudan require less cognitive load from students, which reduce working memory in reciting and recalling multiplication facts.

This linguistic feature of plural marking can be recognised when we read the multiplication tables in Korean and English. For example, 2×6 =12 is read as "two sixes are twelve". The numeral is used in conjunction with nouns to indicate the number of the entities being spoken of; in this case, two sixes. Nouns are made plural by adding a –*es* to the end of the word six, to emphases the quantity of six. Another way of reading it is "two times six is twelve", which indicates the arithmetic operation "times", a verb. The grammatical structures are different in describing the same multiplication sentence. Plural marking is not used in Korean, 2×6 is read as 이 육 십이 (*i yuk sip i*), which simply means two six ten-two, a sequence of numbers.

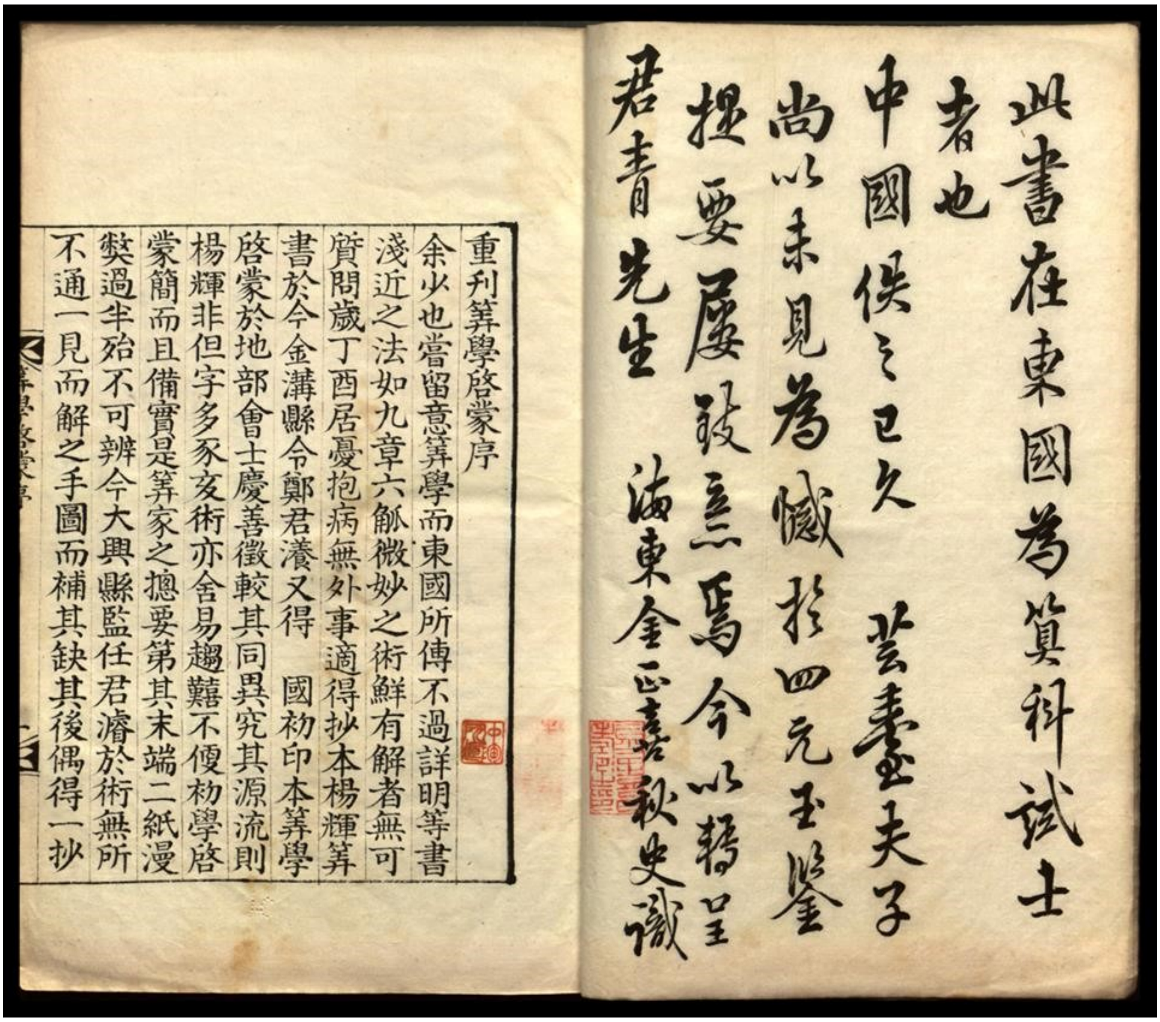


Figure 2b. Introduction to Mathematical Studies 신편산학계몽총괄

Table 4. Two Times Table

	신편 산학계몽 총괄	구구단	Times table of two
2×1=2	二一如二	이 일은 이	One two is two (1×2=2)
2×2=4	二二如四	이 이는 사	Two twos are four (2×2=4)
2×3=6	二三如六	이 삼은 육	Three twos are six (3×2=6)
2×4=8	二四如八	이 사는 팔	Four twos are eight (4×2=8)
2×5=10	二五一十	이 오는 십	Five twos are ten (5×2=10)
2×6=12	二六一十二	이 육 십이	Six twos are twelve (6×2=12)
2×7=14	二七一十四	이 칠 십사	Seven twos are fourteen (7×2=14)
2×8=16	二八一十六	이 팔 십육	Eight twos are sixteen (8×2=16)
2×9=18	二九一十八	이 구 십팔	Nine twos are eighteen (9×2=18)

FINDINGS: THE LEXICOGRAMMATICAL AND SEMANTICS FEATURES OF THE LANGUAGE OF MULTIPLICATION

Mathematics register is a way of using language to express concepts and ideas. It is believed that the uses of ambiguous words in mathematics education, including classroom interaction and written materials, may contribute to students' poor performance and anxiety in mathematics (Durkin & Shire, 1991). The vocabulary of the mathematical registers used in describing the operations of multiplication may have different meanings in

Figure 3. Bae 배, the multiplicative situation

mathematical language and natural language. For example, the Korean word 배 (*bae*) means ship or stomach but 두 배 (*dul bae*) means double. The syntax in framing the mathematical problems and the way we express the multiplication symbol also play an important role in the language of multiplication.

Vocabulary

Multiplicative comparison (Greer, 1992) is another type of multiplicative situation presented in the textbook, verbally expressed by "*n* times as many as" of two quantities of any type. In this example (see **Figure 3**), Yoonseo 윤서 has 2 marbles. Minsu 민수 has 4 times as many marbles as Yoonseo. How many marbles does Minsu have? The notion of bae배 is the same as multiples (배수 in Korean) and it is introduced before the learning of multiplication facts. For example, "2의 4배는 8" means the quadruple of 2 is 8. Bae 배 does not have an equivalent when translated into English but roughly means "times as much / many as", where 두 배 (*dul bae*) means double, 세 배 (*set bae*) means triple, 네 배 (*net bae*) means quadruple, 다섯 배 (*daseot bae*) means quintuple etc. A native numeral must be attached to the suffix, *bae*, which distinguishes the number of the multiplicative factor in the sentence. In this case, the relationship of the two quantities is represented by a native numeral 네 (*net*), 네 배 (*net bae*) 4 times, while the other two numbers 2 and 8 are represented by Sino-Korean 이 (*i*) and 팔 (*pal*). This highlights the multiplicative factor of the two quantities in the number sentence when speaking verbally. The mathematical term bae 배 helps students to connect the idea of the multiplicative factor, and to conceptualise the thinking about the multiplicative situations in quantifiable terms. In contrast, the English terms: double, triple, quadruple, quintuple etc. have their prefixes taken from Latin names of the numerals, and the suffix, -*ple* originated from Medieval Latin, meaning more. These meanings are unclear to students when they come across these linguistic features for the first time.

Table 5. Mathematical Registers

Tuple			Shapes		
Single					
Double	두 배	*dul bae*			
Triple	세 배	*set bae*	Triangle	삼각형	*sam kakhyeong*
Quadruple	네 배	*net bae*	Quadrilateral	사각형	*sa kakhyeong*
Quintuple	다섯 배	*daseot bae*	Pentagon	오각형	*o kakhyeong*
Hextuple	여섯 배	*yeoseot bae*	Hexagon	육각형	*yuk kakhyeong*
Septuple	일곱 배	*ilgop bae*	Heptagon	칠각형	*chil kakhyeong*
Octuple	여덟 배	*yeodeol bae*	Octagon	팔각형	*pal kakhyeong*
Nonuple	아홉 배	*ahop bae*	Nonagon	구각형	*gu kakhyeong*
Decuple	열 배	*yeol bae*	Decagon	십각형	*sip kakhyeong*

According to Halliday (1978), mathematical registers can be developed by reinterpreting existing everyday words with specific mathematics meaning. For example, in Korean, the naming of geometrical figures, triangle (삼각형: *sam kakhyeong*) and quadrilateral (사각형: *sa kakhyeong*) can be literally translated as "three-corner-shape" and "four-corner-shape", where an everyday word such as corner is used, and explicitly denoting the features of the triangle and the quadrilateral and how the shapes are named (see **Table 5**). In the case of multiplication, the word bae 배 produces clarity by using compound words to present multiplicative comparison situations. This helps students to focus on the nature of the relationship between two quantities rather than the specific arithmetic operations. Also, notice that the numerals used for verbal expression in this case is native Korean, which can be easily distinguished from other numbers in the sentences. The use of bai (ばい) as an interpretation for multiplication can also be found in a Japanese textbook series (Watanabe, 2003), indicating the language differences between English and East Asian languages.

Symbol × and Syntax

The interpretation of symbolic expressions

When the multiplication symbol '×' is introduced, a decision must be made over the precise verbal interpretation that is to be used if ambiguity is to be avoid. 3 × 4, meaning four groups of three (see **Figure 4**), is read as 삼 (곱하기) 사 (*sam kop-haki sa*) in Korean. 곱하기 (*kop-haki*) is the only term used to represented the operation of multiplication. In contrast, there are many different interpretations of the multiplication symbol in English language, as explained in Anghileri's "The language of multiplication and division" (1991). For example, when one says '3 times 4', which refers to a group of 4 elements taken 3 times (i.e. 4+4+4), can also be said as: 3 groups of 4, 3 fours, 3 by 4. However, the same multiplication sentence 3 × 4 can also be said as '3 multiplied by 4' which refers to a group of 3 elements taken 4 times, 4 groups of 3 (i.e. 3+3+3+3). In fact, '3 times 4' and '3 multiplied by 4', represents an active and passive constructions respectively, which signify different multiplicative situations. First '3 times 4' can be illustrated as '3 children have 4 cookies each. How many cookies do they have altogether?' (Greer, 1992). This problem can naturally be conceived as 3 groups of 4, where the number of cookies represents the multiplicand that is repeatedly summed up, and the number of children represents the multiplier which is the number of times the multiplicand must be successively added, i.e. 3×4=12. Note that, the multiplier is usually written before the multiplicand in the English speaking world, which appears to be based on the language, since it seems to be more natural to interpret this as "3 times" of a group of 4. As we can see, the two numbers play different roles which are attached to different referents in problem content (Kaput, 1985). According to Greer (1992), this is known as the asymmetrical situations where the multiplier and multiplicand can be distinguished. In "equal groups" situation, the number of objects in each group is the multiplicand and the number of groups is the multiplier. Unlike the commutative relationship which exists between two numbers in a numerical multiplication, the numbers in a word problem cannot be reversed without changing the meaning of the problem. Consequently, multiplication is psychologically non-commutative in a problem solving context (Mangan, 1986). Hence, the position of the multiplier and multiplicand of the number sentence matter if we are dealing with asymmetrical multiplication situations. When the student understands the communicate rule for multiplication, 3×4 and 4×3 generates the same product, the discrepancy between the two expressions will be less important. But for the student struggling to attach some meaning to symbolic arithmetic expressions, the ambiguity may present a considerable barrier to understanding. A consequence of the asymmetrical situation is that two types of division may be

Figure 4. Multiplication of 3, equal groups situation

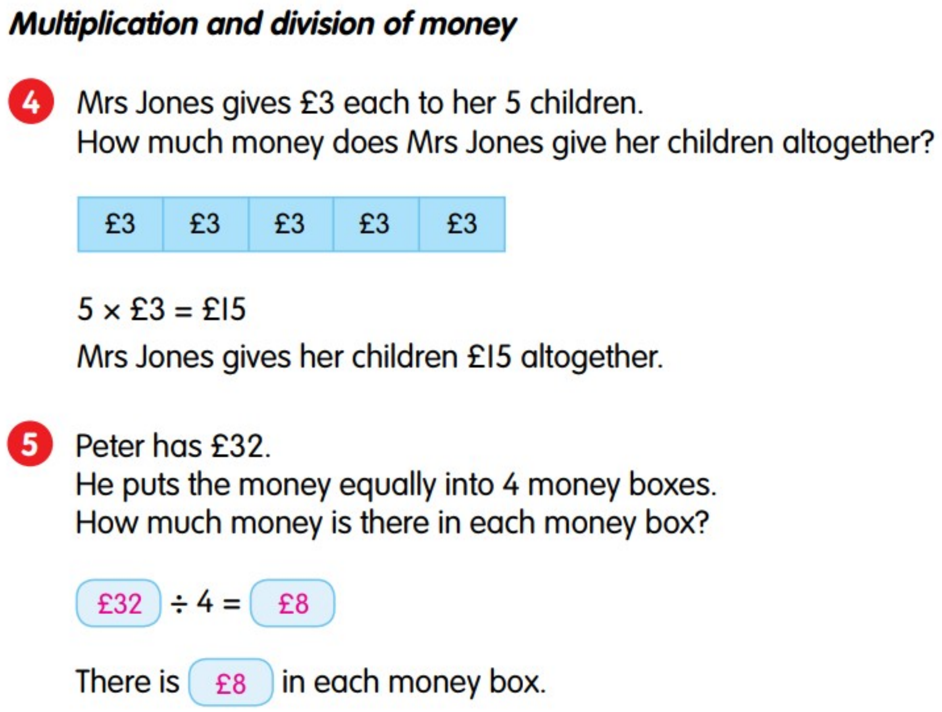
distinguished. Dividing the total by the number of groups to find the number in each group is called partitive division, which corresponds to the familiar practice of equal sharing. For example: 12 cookies are shared equally among 3 children (multiplier), how many does each one get? Dividing the total by the number of each group to find the number of group is called quotitive division. For example: if you have 12 cookies, how many children can give 4 cookies (multiplicand) (Greer, 1992)? Understanding precisely the implication of a variety of phases and emphasising the distinction between multiplicand and multiplier are essential if students are to interpret correctly multiplicative situations that they later meet. This also gives students a better foundation for later development in multiplicative concepts such as part-whole relationships and fractions.

Active and passive constructions

As discussed, 'multiply by' and 'multiplied by' refers to different multiplication situations. According to Beilin (1975), active sentence forms are easier than passive sentence forms in both their comprehension and their production. Hence, the word 'times' is more popular than 'multiplied by' in the language of multiplication. Hence, 3 times 4 may appear to children to be an easier construction to understand than 4 multiplied by 3, the more formal language of multiplication. Lee (2006) believed that it is often the syntax of the conventional style that causes problems for students engaging with mathematics. The use of the passive voice and deletion of personal pronouns is a feature of mathematical discourse and these contribute to the 'distant authorial voice' (Morgan, 1995, p. 14) which is common in mathematical texts. For example, the area of a rectangle is equal to the length (3cm) multiplied by the width (4cm). She also pointed out that "using the passive voice in mathematics, when pupils are unfamiliar and inexpert users of it in English language lessons, is another barrier to pupils feeling that they are able to read about and use mathematical concepts." Passive voice is not used in the language of multiplication in Korean.

Semantics of Multiplication Language

As we have mentioned earlier, students in Korea are taught always to write the multiplicand (the size of a group) before the multiplier (the number of groups). But in the English speaking world, the multiplier is usually placed before the multiplicand, see **Figure 5** for example, which is opposite to the Korean notation. The Korean way by putting the size of a group first then the number of groups is the same as how they read the multiplication tables, and this makes it easier for students to recall multiplication facts to solve problems. Although Korean emphasises the role of the multiplicand and multiplier explicitly, the commutative property is investigated after the learning of basic facts of 2s, 5s and 3s. In **Figure 6**, the butterflies are arranged in a rectangular array with rows and columns, and we say it is a 3 by 4 array, while the terms 'row' and 'column' may present difficulties in English (Anghileri, 1991). In Korean, the word 줄 (*chul*) literally means 'a line', and is used to represent both 'row' and 'column'. The two numbers multiplied play equivalent roles, and they are not distinguishable as multiplicand and multiplier. If we recall the fact families of 4s and 5s:


Multiplication and division of money

4 Mrs Jones gives £3 each to her 5 children.
How much money does Mrs Jones give her children altogether?

£3	£3	£3	£3	£3

5 × £3 = £15

Mrs Jones gives her children £15 altogether.

5 Peter has £32.
He puts the money equally into 4 money boxes.
How much money is there in each money box?

£32 ÷ 4 = £8

There is £8 in each money box.

Figure 5. Textbook example from UK - Inspire Maths

Figure 6. Multiplication of 5, rectangular array situation

4 × 5 = 20 is said as 사 오 이십 – four five two-ten

5 × 4 = 20 is said as 오 사 이십 – five four two-ten

As we can see, the syntax of Gugudan provides a useful representation for making the properties of multiplication, such as commutativity, visible. Another interesting point to note is that vertical multiplication notation is not used for single-digit numbers multiplication in the Korean series. We believe it may be due to the language factor, because when one can easily recall multiplication facts from the tables to solve problems, it seems more natural to 'fill-in' the missing number when the multiplication sentence is presented horizontally. For example: 4 × □ = 28.

DISCUSSION AND CONCLUSION

"Mathematics is a language." This metaphor suggested by Pimm (1987) believes mathematics is best understood as a register (see Halliday, 1978) that carries a set of meaning that is appropriate to a particular function of language. In this study, we examined the linguistic and cultural factors that we believe may influence students' learning multiplication. It should be said clearly that we do not mean that English-speaking students are limited by their language in the learning of multiplication concepts. This is just an example of how we can study the learning of a specific mathematics topic from a language perspective. Both Sino-Korean and native Korean number systems that directly reflect the base-ten nature are regular and transparent, and the dual systems are used interchangeably. Our findings have showed that these systems give students the referents of the numbers in context, whether they are referring to numerals, quantities, or even relationships between quantities. The ancient multiplication table – Gugudan, written in Sino-Korean numerals- have single-syllable number words and simple sentence - Structure that is easy to understand and memorise. The lack of plural marking and passive voice also make the multiplication tables, as well as mathematical texts in multiplication, straightforward and less ambiguous. The use of classifiers in word problems makes the referent clear, increases coherence to the objects and assigns them to a set, which helps the students to visualize what the problem is asking for, whether it is the number of animals 마리 (*mali*) or the number of people 명 (*myeong*). We have also identified other distinguishable features, including the mathematical term, Bae배, which can also be found in Chinese and Japanese languages to represent multiplicative comparison situations. Here, a native Korean numeral is used to represent the multiplicative factor, which can be conceived as the multiplier. It can be differentiated easily from other numerals in the mathematical texts or word problems. We believe the use of bae배 has greater impact on students' development of multiplicative concepts. Bae 배 represents a constant relation of one-to-many correspondence between two sets, the invariant relationship between two quantities. By emphasizing this multiplicative factor, or constant, at an early stage may help students in making the transition from multiplicative reasoning to proportion reasoning, such as rate and ratio. Moreover, we believe the results reported in this paper have a number of implications for a further development of linguistics study in the learning of mathematics.

First, research in the Learner's Perspective Study (LPS) has made clear just how culturally-situated are the practices of mathematics classrooms around the world; the classroom is a site through which the international mathematics education community can explore considerations of culture, language, temporality and theory (e.g., Clarke, Keitel, & Shimizu, 2006). However, LPS focuses on the eighth grade, without considering the classroom practices and discourses in elementary schools. In fact, Koreans, Japanese and Chinese have a lot of similarities in terms of the language of mathematics, and many problem solving strategies seem to be common, especially in elementary school mathematics. Hence, we would like to extend our study to reveal the subtle and pervasive effects of culture and language that shape and constitute certain practices as they impinge on students' early mathematics development.

Second, this study strengthens the foundation of our research on language and mathematics education. Although the discussion here is of limited scope and does not give a complete account of the language instruction of multiplication, our findings provided us with the basis for our wider study on Korean classroom, and to extend our understanding of how language, cultural practices and sociocultural processes may influence students' learning. The documented data served to ground the research in the context of our wider investigation. Information contained in these documents suggested the teaching sequences and strategies that needed to be observed. Results from the document analysis are particularly useful in understanding classroom discourses. Our empirical data from other studies has shown that most Korean students already acquire some knowledge of multiplication before their formal learning in school. They could memorise multiplication facts through Gugudan related songs and games at home and throughout their kindergarten years. Students solve multiplication problems based on the way Gugudan is written. Therefore, without a good understanding of the linguistic features of Korean numerals and multiplication tables, it would be difficult (if not impossible) to analyse classroom discourses and students' problem solving strategies in the classroom.

Finally, we would like to highlight the importance of language analysis in international comparative studies. TIMSS has provided us with extensive information about educational policies and practices in and across countries. It aims at examining students' competence according to the school curriculum (Leung, 2014), and has the content areas and processes that are typically associated with school mathematics. In the grade 4 assessment, it emphasises items which require the reproduction of facts or standard algorithms, and has a larger number of items focusing on Number and Measurement (Ruddock, Clausen-May, Purple, & Ager, 2006). These items (which include multiplication, division, ratio, rate, fraction, proportional reasoning) are related to multiplicative conceptual fields defined by Confrey (1994) and Vergnaud (1983, 1988). As pointed out in this paper, the forms and constructions of Korean language in the learning of multiplication do not always have exact counterparts in English. The regularity of the number systems and simplicity of mathematical registers may influence Korean students' learning mathematics and hence their mathematics achievement. The interaction between linguistic, conceptual and social aspects of students' learning is complex. Difficulties posed by the language in which mathematics is expressed adversely affect students' conceptualization of mathematical notions. The lack of research in the language of mathematics, in particular TIMSS items, may lead to misinterpretation of the data, and thus care should be taken when translating results from these studies. Previous research on East Asian student achievement in cross-national studies focuses on cultural factors (e.g. Leung, 2001, 2002, 2006), namely the Confucian Heritage Culture (CHC) (Biggs, 1996). Cultural values held by East Asians were believed to be the possible explanation for high student achievement. They include a strong emphasis on education and examination culture (Cheng, 1994), belief in effort (Stevenson, 1987), the stress on practice and memorization (Biggs, 1996), and teacher competency and qualification (Leung, 2001; Leung & Park, 2002) etc. These studies ignore any linguistic factors, both systemic and institutional (Halliday, 1978) that underpin the learning of mathematics. We believe the study of the mathematical functionality of the natural languages, and the possible sources of the linguistics features facing the mathematics learners, requires more attention. In part, why East Asian students performed better in certain domains / items could be studied from linguistic and cultural perspectives.

We wish the research findings in this present study to serve as an important reference for future studies in this under-researched field of the influence of culture and language on mathematics learning and achievement. This study only addresses the treatment of multiplication in the student textbooks and teachers' manuals. Examination of how teachers actually teach and students learn in class are beyond the scope of this study. Although more work needs to be done, our initial findings support our hypothesis that the clarity of the Korean language supports the learning of multiplication.

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A Bibliometric Analysis of the Papers on Urban Education

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ABSTRACT

Researchers generated a comprehensive list of the articles published between 2010 and 2017 in the field of 'urban education' by searching the Social Sciences Citation Index database, using the keywords of "urban" and "education". Only the articles that were under the categories of "education, educational research", "education scientific disciplines", "psychology educational", and "education special" were included. As an additional criterion, all the articles published between 2010 and 2017 in the journals of "Urban Education" and "Education and Urban Society" were included. The researchers examined these articles according to a few criteria such as h-classics publications, authors, organizations, country of origin, article types, research areas, and journal titles. There is the total of 2123 publications that were checked and retrieved in the field of "urban education" between 2010 and 2017. Although the number of publications differs year by year, the sum of the citations received the increase from year to year on a regular basis. There are 35 articles, that was cited more than h-index, as h-classics in this field for this period and top ten of these h-classics are reported in this study. "Urban Education" and "Education and Urban Society" were revealed as the most prominent journals in the field of urban education. Also, the results show that the most cited articles, the most prolific authors and organizations, and top journals in this field are from the USA. Also, when we look at the overall record for the countries of origin, the USA has an overwhelming superiority in this field. This bibliometric analysis contributes to the literature of urban education through a historical perspective. Results show that the "urban education" field attracts more attention of the researchers and the impacts of these publications are increasing from year to year. Also, there is a prevalence of the USA in the field of urban education.

Keywords: urban education, bibliometric analysis, citation analysis

INTRODUCTION

Urban science is an interdisciplinary area of study that deals with urban issues and problems such as a history, economics, education, administration, architecture, urban engineering, transportation engineering, landscape architecture, environmental engineering, sustainability, sociology, and geo-informatics (Asdrubali et al., 2018; Lima et al., 2018; Hassan & Lee, 2018; Jiang et al., 2017; Shandas et al., 2017).

Urban education refers to schools geographically situated within urban areas (Alston, 2002). Urban education is related to the schools which function to serve the needs of industrial-business driven, commercial society (Rothstein, 1996). Urban schools are located in urban environments, reflect the characteristics and response to the needs of this metropolitan society, bureaucratic and hierarchical by nature, and suffer from the issues of class and race/ethnicity (Obiakor & Beachum, 2005). Urban education refers to schools geographically situated within urban areas (Alston, 2002). Urban education is related to the schools which function to serve the needs of industrial-business driven, commercial society (Rothstein, 1996). Urban schools are located in urban environments, reflect the

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Contribution of this paper to the literature

- There are 35 articles which have h-index higher than 36 in the urban education field between 2010 and 2017. These are the h-classics in this field for this period. However, top 10 of the h-classics are reported in this paper.
- The most cited articles, the most prolific authors and organizations, and top journals in this field are from the USA. Also, when we look at the overall record for the countries of origin, USA has an overwhelming superiority in this field. Various issues in urban education draw the attention of the researchers from the USA than the ones in any other country in the world.

characteristics and response to the needs of this metropolitan society, bureaucratic and hierarchical by nature, and suffer from the issues of class and race/ethnicity (Obiakor & Beachum, 2005).

Urban schools are generally diverse, complex, striving against growth and have a high amount of student enrolments. These schools are inevitably affected by the environment created by the urban context (Noguera, 2004) and are linked to more significant social issues that have historical origins (Obiakor & Beachum, 2005). The subjects of urban education research are generally related to broader political, economic, and structural issues (Ginwright, 2004). In particular, urban education is an education scientific field about how various tools might be useful as the researchers investigate problems through the various areas of emphases associated with urban education: educational policy; psychology and human development; curriculum and instruction; equity; counselling and social services; leadership; special education; and teacher education (Milner, 2012).

Most urban education researchers aim to do work that encourages, produces and informs change in educational policy, practice, and the conditions that shape them. Furthermore, at the heart of the field called as ‘‘urban education research’’, there is an orientation toward social change to bring about equity, access, and fairness (Nygreen, 2006). Furthermore, modern urban education research is grounded in broader social, cognitive, cultural, economic, and political contexts, and view urban schools as part of a broader set of human services and community development (Kincheloe, 2010).

The aim of this study is identifying the papers published on urban education field and analysing the characteristics of these papers to contribute to the urban education research over the recent years. This paper uses ‘bibliometric analysis’ to identify and analyze the publications in this field of research (Thibaut et al., 2018).

The term “bibliometrics” was first defined by Pritchard (1969) as “the application of mathematical and statistical methods to books and other media of communication”. Bibliometrics is an effective method to analyse the research trend of a specific field. In a bibliometric analysis, publications are grouped according to their characteristics such as; the number of citations received, the name of authors, the name of journals, countries of origin, the name of institutions, article types, and research areas.

The number of citations received is among the most important indicators used in the bibliometric analysis. An article gets a ‘citation’ when another peer-reviewed article references it. The rate of this citation is a significant way to show the importance of an article. The total number of citations that an article receives has been viewed as a measure of the influence of the article in the related field (Marx, Schier, &Wanitschek, 2001).

This study used Web of Science (WoS) to find the publications in urban education. The Institute for Scientific Information (ISI) has been collecting citations and other academic impact information since 1945 and has been available electronically since 1979. ISI calls their newest journal citation system “Social Sciences Citation Index (SSCI)”. It is one of the databases available at the site of Web of Science.

MATERIALS AND METHODS

On February 13, 2018, researchers generated a comprehensive list of the articles published between 2010 and 2017 in the field of ‘urban education’ by searching Web of Science. The keywords of “urban” and “education” were searched in the “topic” field. It means that the articles containing “urban” and “education” -in their titles, abstracts, author keywords, and keywords plus- were extracted. Citation Indexes in Web of Science Core Collection were restricted to the “Social Sciences Citation Index (SSCI)” database. Only the articles that were under the categories of “education, educational research”, “education scientific disciplines”, “psychology educational”, and “education special” were included in the research. Also, all the articles published between 2010 and 2017 in the journals of “Urban Education” and “Education and Urban Society” were included in this study as an additional search criterion. Because these are the only journals in SSCI index publish only the articles about urban education. The retrieved articles were cross-checked by the authors if they are really about urban education or not. At the final stage, only the ones that are really about urban schools or urban education issues were included and analyzed.

Table 1. Record counts and percentages by publication years

Publication Years	Record Count	% of 2123
2017	301	14.18%
2016	296	13.94%
2013	284	13.38%
2014	263	12.39%
2015	263	12.39%
2011	255	12.01%
2012	241	11.35%
2010	220	10.36%

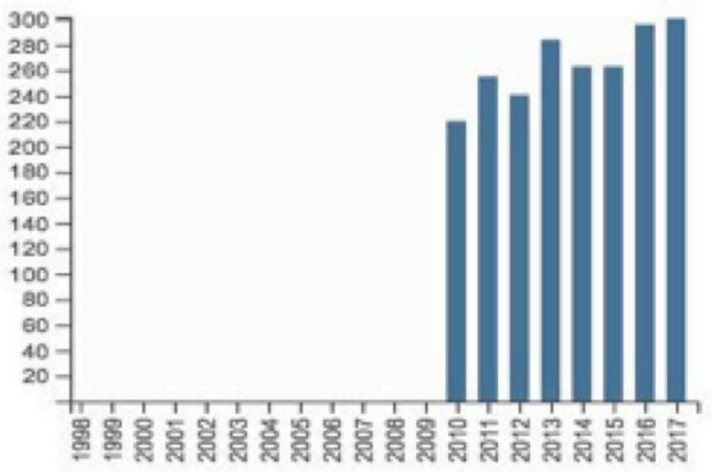

Figure 1. Total publications by year

The authors employed "bibliometric analysis" to determine and examine the features of the articles in "urban education" topic. Bibliometric analysis is a kind of statistical method to examine the quantitative properties of bibliographic information, journals, articles, and literature (Narin & Hamilton, 1996). In this study, some of the bibliometric analysis indicators were used such as; h-index, h-classics publications, most productive authors, organizations, country of origin, article types, research areas, and journal titles.

In this study, citation analysis was employed to extract h-index and h-classics. Citation analysis is a way to evaluate the impact of research because it measures the impact of a series of papers written by an author or a university (Podsakoff, MacKenzie, Podsakoff, & Bachrach, 2008).

The h-index is a useful index to characterize the scientific output of a researcher and defined as the number of papers with citation number ≥h (Hirsch, 2005). The h-index is an indicator which combines publications with their citations. It implies that the number of studies X that have received X or more citations (Cancino, Merigó, & Coronado, 2017). For example, if there is a series of publications with an h-index of 8, there are 8 articles that have been cited 8 times or more. It means there are not 9 publications or more that have been cited at least 9 times.

Another way to report the papers with high quality is determining the "h-classics" of a field. The concept of "h-classics" was first introduced by Martínez et al. (2015). H-classics publications include h highly cited papers with more than h citations. The indicator of h-classics is among the most popular ones to highlight the quality of the journals, researchers, and publications (Cobo et al., 2014). Therefore, the indicator of h-classics was used in this study to determine the high-quality publications in the field of urban education.

RESULTS

General Review of the Publications

Total of 2123 publications was checked and retrieved in the field of 'urban education' between 2010 and 2017. Year by year, the number of publications differ (**Table 1**, **Figure 1**). The years of 2010 (220), 2012 (241), and 2011 (255) have the least number of publications, while the years of 2017 (301), 2016 (296), and 2013 (284) have the largest number of publications.

Table 2 shows the document types retrieved and selected for this study. Most the publications retrieved and selected for this study are articles (2004, %94.4). There are 46 editorial materials (%2.17), 37 book reviews (%1.74),

Table 2. Document types

Document Types	Record Count	% of 2123
Article	2004	94.40%
Editorial Material	46	2.17%
Book Review	37	1.74%
Review	33	1.55%
Proceedings Paper	4	0.19%
Book Chapter	3	0.14%
Correction	3	0.14%

Table 3. "Web of Science" categories on research areas

Web of Science Categories	Record Count	% of 2123
Education Educational Research	1945	91.62%
Education Scientific Disciplines	152	7.16%
Psychology Educational	90	4.24%
Education Special	49	2.31%

33 reviews (%1.55), 4 proceeding papers (%0.19), 3 book chapters (0.14), and 3 corrections (0.14). The materials other than the articles were included in this study because some of these studies have serious numbers of citations which mean they have a serious impact in this field.

Table 3 shows the "Web of Science" categories for the publications retrieved and selected for this study. Most of the publications that were checked and selected for this study were in the category of "education – educational research" (1945 items, %91.62). The other publications are in the categories of "education scientific disciplines" (152 items, %7.16), "psychology educational" (90 items, %4.24), and "education special" (49 items, %2.31).

H-Classics Publications Analysis

For this study, there was totally 2123 publications, average citation per item was 5.65, the sum of times cited was 11998, the sum of times without self-citations was 10961, and h-index was calculated as 36. Therefore, the articles with have citations higher than h-index were reported as h-classics in this study.

According to the results, there are 35 articles which have h-index higher than 36 in the urban education field between 2010 and 2017. According to the citation report, top 10 of the h-classics are reported in **Table 4**. Four of these ten most cited publications are about science education in urban areas: one from the "Journal of Research in Science Teaching", two from the "Science Education", one from the "Journal of the Learning Sciences". In overall, there are two articles from the "Urban Education", one from the journals of "Educational Administration Quarterly", "Educational Psychologist", "Journal of School Health", and "Child Development".

Table 4. Top 10 h-classics publications in urban education field between 2010 and 2017

Results found	**2123**			
Sum of the Times Cited	11998			
Average Citations per Item	5.65			
h-index	36			

Title	Authors	Source Title	Publication Date	Total Citations
Inquiry-Based Science Instruction-What Is It and Does It Matter? Results from a Research Synthesis Years 1984 to 2002	Minner, Daphne D.; Levy, Abigail Jurist; Century, Jeanne	Journal of Research in Science Teaching	Apr 2010	247
How Principals and Peers Influence Teaching and Learning	Supovitz, Jonathan; Sirinides, Philip; May, Henry	Educational Administration Quarterly	Feb 2010	105
Scientific Discourse in Three Urban Classrooms: The Role of the Teacher in Engaging High School Students in Argumentation	McNeill, Katherine L.; Pimentel, Diane Silva	Science Education	Mar 2010	90
A Meta-Analysis of the Efficacy of Different Types of Parental Involvement Programs for Urban Students	Jeynes, William	Urban Education	Jul 2012	85
Confronting the Marginalization of Culturally Responsive Pedagogy	Sleeter, Christine E.	Urban Education	May 2012	82
Cultural Processes in Science Education: Supporting the Navigation of Multiple Epistemologies	Bang, Megan; Medin, Douglas	Science Education	Nov 2010	82
Do Learners Really Know Best? Urban Legends in Education	Kirschner, Paul A.; van Merrienboer, Jeroen J. G.	Educational Psychologist	Jul 1 2013	80
Healthier Students Are Better Learners: A Missing Link in School Reforms to Close the Achievement Gap	Basch, Charles E.	Journal of School Health	Oct 2011	74
Child Development in Rural China: Children Left Behind by Their Migrant Parents and Children of Nonmigrant Families	Wen, Ming; Lin, Danhua	Child Development	Jan-Feb2012	71
We Be Burnin'! Agency, Identity, and Science Learning	Barton, Angela Calabrese; Tan, Edna	Journal of the Learning Sciences	2010	71

The most cited article is "Inquiry-Based Science Instruction-What Is It and Does It Matter? Results from a Research Synthesis Years 1984 to 2002" by Minner, Abigail, and Century (2010) from the USA with 247 citations. This article developed a conceptual framework that clarifies and specifies what is meant by "inquiry-based science instruction," and used a mixed-methodology approach to analyze both numerical and text data describing the impact of instruction on K–12 student science conceptual learning in urban schools. Various findings across 138 analyzed studies showed a positive trend favouring inquiry-based instructional practices.

The second most cited article is "How Principals and Peers Influence Teaching and Learning" by Supovitz, Sirinides, and May (2010) from the USA with 105 citations. This article examines the effects of principal leadership and peer teacher influence on teachers' instructional practice and student learning and used data from an urban school district in the United States. The results show the importance of principals' efforts for student learning in urban schools because of their indirect influence on teachers' practices through the fostering of collaboration and communication around instruction.

The third most cited article is "Scientific Discourse in Three Urban Classrooms: The Role of the Teacher in Engaging High School Students in Argumentation" by McNeill and Pimentel (2010) from the USA with 90 citations. This article examines the discourse in urban high school science classrooms in which the teachers used the same global climate change curriculum. The results indicated that teachers' use of open-ended questions plays a significant role in supporting students in argumentation; it provides evidence and reasoning for students' claims and encourages dialogic interactions between urban high school students.

Figure 2 shows there are how many citations for the publications in the urban education field each year. According to the results, although the number of publications differs year by year (**Table 1**, **Figure 1**), the number of citations of these publications in this field are increasing on a regular basis from year to year. It shows that the impacts of these publications in the literature are increasing and various issues in urban education field attract more attention from year to year.

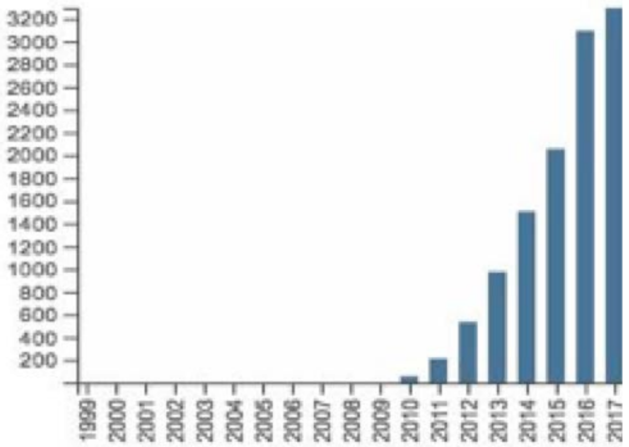

Figure 2. Sum of times cited by year

Table 5. The most prolific organizations

Organizations-Enhanced	Record Count	% of 2123
University of California System	91	4.29%
University of Texas System	71	3.34%
University of Wisconsin System	57	2.69%
City University of New York Cuny System	53	2.50%
Pennsylvania Commonwealth System of Higher Education Pcshe	53	2.50%
University of North Carolina	52	2.45%
California State University System	51	2.40%
Columbia University	51	2.40%
University of Illinois System	50	2.36%
State University System of Florida	45	2.12%

The Most Prolific Organizations, Authors, Journals, and Countries

In this section, according to the number of publications in the field of urban education between 2010 and 2017, the most prolific organizations, authors, journals, and countries are reported. **Table 5** shows the ten most prolific organizations. The most prolific one is "University of California System" with 91 publications (4.29%), the second one is "University of Texas System" with 71 publications (3.34%), and the third one is "University of Wisconsin System" with 57 publications (2.69%), the fourth and fifth ones are "City University of New York Cuny System" and "Pennsylvania Commonwealth System of Higher Education PCSHE" with 53 publications each (2.5%). The sixth one is "University of North Carolina" (53, 2.45%), the seventh and eighth ones are "California State University System" and "Columbia University" (51 publications each, 2.4%), ninth one is "University of Illinois System" (50, 2.36%), and the tenth one is "State University System of Florida" (45, 2.12%). All of these universities are from USA. It shows the impact of USA universities in the field of urban education in the last 7 years.

Table 6 shows the top ten most prolific authors in the field of urban education between 2010 and 2017. The most prolific author in this field is Milner, H.R. from University of Dayton, USA, with 16 publications (0.75%). He is also the editor of the journal of "Urban Education". Some of his editorials receive more than citations than most of the articles in this field. For example, one of his editorials titled as "But What is Urban Education" (2010) are among the h-classics in this field with 41 citations. So, we did not exclude these editorials. The second most prolific author is Lomotey, K. from University of Western Carolina, USA, with 13 items (0.61%), the third one is Gottfried, M.A. from University of California, USA, with 11 items (0.52%), the fourth one is Lee, O. from University of Miami, USA, with 9 items (0.42%), the fifth one is Naraian, S. from Columbia University, USA (7 items each, 0.33%). Sixth, seventh, eighth, and ninth ones are Basch, C.E. from Columbia University, USA; McCaughtry, N. from Wayne State University, the USA; McNeill, K.L. from Boston College, USA; and Shen, B. from Wayne State University, USA (6 items each, 0.28%). The tenth one is Anderson, L. from Connecticut College, USA (5 items (0.23%). Affiliations of these authors show that all the ten most prolific authors in the field of urban education are working at the USA universities.

Table 6. The most prolific authors

Authors	Record Count	% of 2123
Milner HR	16	0.75%
Lomotey K	13	0.61%
Gottfried MA	11	0.52%
Lee O	9	0.42%
Naraian S	7	0.33%
Basch CE	6	0.28%
McCaughtry N	6	0.28%
McNeill KL	6	0.28%
Shen B	6	0.28%
Anderson L	5	0.23%

Table 7. Top 10 journals in the field of urban education

Source Titles	Record Count	% of 2123
Urban Education	373	17.57%
Education and Urban Society	272	12.81%
Teachers College Record	84	3.96%
International Journal of Educational Development	42	1.98%
Journal of Research in Science Teaching	35	1.65%
Teaching and Teacher Education	35	1.65%
Environmental Education Research	32	1.51%
Journal of Teacher Education	32	1.51%
Educational Policy	31	1.46%
Journal of School Health	31	1.46%

Table 8. Top 10 countries of origin for the publication record in the field

Countries/Regions	Record Count	% of 2123
USA	1517	71.46%
Canada	101	4.76%
England	101	4.76%
Australia	93	4.38%
Peoples R China	72	3.39%
South Africa	50	2.36%
Turkey	33	1.55%
Taiwan	24	1.13%
Netherlands	23	1.08%
Spain	22	1.04%

Table 7 shows the top ten journals in the field of urban education between 2010 and 2017 according to the number of publications. The first two journals, as expected, are the only ones that focus on the urban education field and publish only the articles on this field in SSCI Index; “Urban Education” (373 publications, 17.57%) and “Education and Urban Society” (272 publications, 12.81%). The third one is “Teachers College Record” (84 publications, 3.96%), fourth one is “International Journal of Educational Development” (42 publications, 1.98%), fifth and sixth ones are “Journal of Research in Science Teaching” and “Teaching and Teacher Education” (35 publications each, 1.65%), seventh and eighth ones are “environmental Education Research” and “Journal of Teacher Education’ (32 Publications each, 1.51%), ninth and tenth ones are “Educational Policy” and “Journal of School Health” (31 publications each, 1.46%).

Table 8 shows the top ten countries of origin, for the publications in urban education field between 2010 and 2017, according to the authors’ affiliations. Undisputedly, the most prolific country is USA with 1517 publications (71.46%). Second and third ones are Canada and England (101 publications each, 4.76%), fourth one is Australia (93 publications, 4.38%), fifth one is Peoples’ Republic of China (72 publications, 3.39%), sixth one is South Africa (50 publications, 2.36%), seventh one is Turkey (33 publications, 1.55%), eighth one is Taiwan (24 publications, 1.13%), ninth one is Netherlands (23 publications, 1.08%), and tenth one Spain (22 publications, 1.04%).

DISCUSSION

The aim of this study was identifying all the publications in urban education field between 2010 and 2017 and analysing the characteristics of these papers using bibliometric analysis. Firstly, Web of Science was used to extract all the articles in this field. All the articles using “urban” and “education” in their titles, abstracts, author keywords or keywords plus were retrieved. The categories of WoS were restricted to “education, educational research”, “education scientific disciplines”, “psychology educational”, and “education special”. Only the articles which were published in the journals indexed in SSCI were included in this study. Also, all the articles in the SSCI indexed journals of “Urban Education” and “Education and Urban Society” published between 2010 and 2017 were included. All the articles were reviewed by the authors, and only the ones which are really about “urban education” were included and analysed in this study.

In this study, most of the publications that were retrieved and analysed are articles, and there are small numbers of editorial materials, book reviews, reviews, proceeding papers, book chapters and corrections. Most of the publications in this study are in the category of “education – educational research”. Also, there are small numbers of publications in the categories of “education scientific disciplines”, “psychology educational”, and “education special”. From 2010 to 2017, each year has a different number of publications, whereas, the sum of the citations received the increase from year to year on a regular basis. It shows that the field of “urban education” attracts more attention of the researchers in the literature and the influence of these publications is increasing from year to year.

The results show that there are 35 articles which have h-index higher than 36 in the urban education field between 2010 and 2017. These are the h-classics in this field for this period. However, top 10 of the h-classics are reported in this paper. Four of these ten most cited publications are about science education in urban areas: one from the “Journal of Research in Science Teaching”, two from the “Science Education”, one from the “Journal of the Learning Sciences”. In overall, there are two articles from the “Urban Education”, one from the journals of “Educational Administration Quarterly”, “Educational Psychologist”, “Journal of School Health”, and “Child Development”. The most cited article is “Inquiry-Based Science Instruction-What Is It and Does It Matter? Results from a Research Synthesis Years 1984 to 2002” by Minner, Abigail, and Century (2010) with 247 citations. The second most cited article is “How Principals and Peers Influence Teaching and Learning” by Supovitz, Sirinides, and May (2010) with 105 citations. The third most cited article is “Scientific Discourse in Three Urban Classrooms: The Role of the Teacher in Engaging High School Students in Argumentation” by McNeill and Pimentel (2010) with 90 citations. All of these top three works are from the USA.

Looking at the affiliations of the authors and according to the number of publications, top ten organizations are reported in this paper. The most prolific organization is “University of California System”, the second one is “University of Texas System”, and the third one is “University of Wisconsin System”. Also, all of the top ten universities are from the USA. It proves the influence of the USA universities in this field in the last 7 years.

The most prolific author in this field is Milner, H.R. from University of Dayton, USA. He is also the editor of the journal of “Urban Education”. The second most prolific author is Lomotey, K. from University of Western Carolina, USA, and the third one is Gottfried, M.A. from University of California, USA. Also, all of the top ten authors in the field of urban education are working at the USA universities.

According to the number of publications, the top ten journals in the field of urban education between 2010 and 2017 are listed in this paper. The first two prolific journals are “Urban Education” and “Education and Urban Society”. These are the only journals that concentrate on the urban education field and publish only the items on this field in SSCI Index. The third one is “Teachers College Record”, and the fourth one is “International Journal of Educational Development”.

When we look at the countries of origin for the publications in this field between 2010 and 2017, the USA has unchallengeable the largest number of publications. Second and third ones are Canada and England. In order; Australia, Peoples’ Republic of China, South Africa, Turkey, Taiwan, Netherlands, and Spain follow these countries.

In general, the results show that the most cited articles, the most prolific authors and organizations, and top journals in this field are from the USA. Also, when we look at the overall record for the countries of origin, USA has an overwhelming superiority in this field. Various issues in urban education draw the attention of the researchers from the USA than the ones in any other country in the world. Kincheloe (2010) explained the reasons of the recent popularity of urban education research in the USA as; the researchers find “the emergent American culture” in the urban context and the USA faces an uncertain future because of a wide diversity of problems in more than 200 urban areas in all over the country. Researchers in the USA try to understand the urban education context deeply to find solutions for the various issues of urban education.

The authors acknowledge that this study may have possible methodological limitations. The survey was limited to the keyword of “urban education” in the fields of title, abstract, author keywords and keywords plus. Although all the publications in the journals of “Urban Education” and “Education and Urban Society” were added in the analysis, there may still be other publications which are related to the urban education field in the SSCI indexed journals. Despite the possible limitations, the information presented in this paper provides insight into the development of urban education research over the recent years.

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Outcomes of a Drug Dosage Calculation Training Smartphone App on Learning Achievement, Metacognition, and Flow State According to Prior Knowledge

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ABSTRACT

The purpose of this study was to define the effectiveness of a smartphone-based dosage calculation training app on nursing students' learning achievement, metacognition, and flow based on prior knowledge. The study used a quasi-experimental design with a pre- and post-test. Participants were 157 nursing students from 3 universities with baccalaureate programs in South Korea. After recruiting the experimental and control groups, they were also categorized by prior knowledge of drug dosage calculation ability into above and below-mean clusters. The experimental groups were provided with the smartphone-based app. In the above-mean cluster, changes in total learning achievement (Z=3.16, p=.002), drop rate calculation (Z=2.76, p=.006), metacognition (Z=2.50, p=.012), and flow score (Z=2.42, p=.016) in the experimental group were significantly higher than those in the control group. A smartphone-based calculation training app improves calculation achievement, metacognition, and flow among students with higher prior knowledge. For learners with lower prior knowledge, additional instructional design or implementation strategies may be needed.

Keywords: cognition, drug dosage calculations, learning, metacognition, smartphone

INTRODUCTION

Medication administration is considered to be one of the most important responsibilities of nurses, for whom dosage calculation competence is a crucial skill, because medication administration errors related to wrong dosage committed by registered nurses are common (Fathi et al., 2017). Nursing students showed relatively low dosage calculation competence in several studies (McMullan, Jones, & Lea, 2010; Özyazıcıoğlu et al., 2017). Further, the mean score of drug calculation skill of registered nurses showed unacceptable results at 60%, and about half of them failed basic numerical skill tests (McMullan et al., 2010). This deficiency may be from insufficient mathematical knowledge and understanding of the correct medication formula for each situation (Coyne, Needham, & Rands, 2013). Therefore, different teaching and learning strategies for dosage calculation education have been developed such as e-learning (Simonsen, Daehlin, Johansson, & Farup, 2014), or mobile technology-based strategies (Liu, Lin, Tsai, & Paas, 2011).

Based on the previous study, mobile technology such as smartphones is considered to be an innovative teaching strategy in both traditional classrooms and learning outside the classroom (Liu et al., 2011), that can be realized due to individualized interfaces, portability, real-time access to information, and feedback. According to the meta-analysis of the use of mobile devices on learning performance with teaching and learning (Sung, Chang, & Liu, 2016), its effect in education of professional subjects or mathematics had a medium effect size. Although several smartphone-based learning apps have been used as educational supplements in healthcare, the majority of research has focused on lower-level knowledge and skill (Mosa, Yoo, & Sheets, 2012), not higher-level knowledge like calculation and evaluation. In addition, most previous studies in this area have examined the effects of smartphone-

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Contribution of this paper to the literature

- This study highlights the necessity for examining not only learning achievement but also prior knowledge and procedural variables such as metacognition, flow when evaluating the effectiveness of a smartphone-based learning app.
- The results show that the drug dosage calculation training smartphone-based app was more effective on learning achievement, metacognition, and flow in the higher prior knowledge group. This means that additional instructional design of smartphone-apps or implementation strategies by instructors may be needed for learners with lower prior knowledge.
- This study is expected to provide insights for smartphone-based learning app development and self-learning guidance for drug dosage calculation.

based educational programs on learning achievement (Sung et al., 2016), overlooking metacognition and flow as procedural outcomes.

Metacognition is called "cognition of cognition" or "higher cognition," and defined knowledge about cognition and regulation of cognition as two components (Carruthers, 2009). First, knowledge about cognition defined as stable knowledge about the learner's own cognitive system, awareness of the current state of cognition, and appraisal of the significance of thought and memories (Wells, 1995). This means that what students know about themselves, the tasks they conduct, and their learning strategies, are essential for self-directed learning. If learners can immediately recall knowledge after learning or perceive the current status of their knowledge and learning strategy, they are regarded as having high metacognition. Learners with high metacognition tend to think themselves as good learners and develop positive beliefs and attitude about their learning (Graham, 2006). Second, regulation of cognition means supervising and managing one's own learning process and understanding of how to regulate those processes to maximize learning achievement (Wells, 1995). Learners having higher metacognitive skills receive better scores on their exams and complete work more efficiently because they utilize effective tools and modify learning strategies and skills based on knowledge effectiveness (Magno, 2010). Based on the previous studies, there were significant changes in metacognitive perception to achieve autonomous learning after augmented- reality-based learning (Cotterall & Murray, 2009), and higher metacognition induces better learning achievement (Ferrer-Torregrosa et al., 2016). Smartphones provide benefits such as individualized interfaces, portability, and real-time access to information; it is helpful that students can improve their metacognition by managing their own learning "just-in-time" and "when-needed."

Flow is understood as a state of optimal experience in which a person derives pleasure from the intrinsic experience of performing a task (Nakamura & Csikszentmihalyi, 2009). Nakamura and Csikszentmihalyi (2009) describe flow as an integrated status of cognitive domain and affective domain; that is, a feeling of enjoyment and immersion, energized focus, and involvement, frequently accompanied by positive affect or pleasure (Hung, Sun, & Yu, 2015). In a flow state, we feel time stand still and lose our sense of self, and enjoy engaging in a performance for its own sake (Kwon, 2008). If learners can concentrate and neglect unrelated thoughts, for example about time, space, or themselves, the learning of flow will occur, leading them to feel pleased and joyful, which is positive for the learning process. Concentration and interest in the activity are needed for flow, and learners may feel flow if they experience enjoyable moments immersed in the joy of learning (Nakamura & Csikszentmihalyi, 2009). According to previous studies, a multimedia-based educational game enhances flow level and high interactivity (Hung et al., 2015), and in particular attracts learners' interests and attention compared to the non-game environment (Sitzmann, 2011).

When developing a dosage calculation educational program for enhancing the calculation skills, it is difficult to address disparate learning needs due to the diverse levels of students (Hutchinson, Mitchell, & St John, 2011). Entry points need to be considered to ensure consistency among students for a similar level of calculation skill. However, it is not easy to find research comparing educational programs' effects by prior knowledge level, which based on one study serves as a necessary and sufficient condition for development of learners' interest in continuing to learn further (Hailikari, Katajavuori, & Lindblom-Ylanne, 2008). Even when the educational techniques in use are well developed, learning performance cannot be accomplished by learners who have lower prior knowledge. Prior knowledge has been considered to be the variable predicting the largest proportion of achievement, and also predicts part of flow (Kang, Kim, Kim, Park, & Koo, 2009). Based on these known relationships, the aim of this study is to answer the research question, "Are there differences in the effectiveness of a smartphone-based dosage calculation training program on nursing students' learning achievement, metacognition, and flow based on prior knowledge?"

METHODS

Study Design

The study used a quasi-experimental design with a pre- and post-test.

Population and Sample

Participants were second-year nursing students, as this app focused on basic drug dosage calculation. Three universities with baccalaureate nursing programs were recruited in a major city in South Korea. The three nursing schools were selected because of similar entrance scores and curricula for medication dosage calculation. The inclusion criteria were as follows: participants had to be second-year nursing students who 1) had learned detailed drug dosage calculation formulae in their subjects, 2) had no experience with medication administration, 3) were female students, and 4) consented to participate. Male students were excluded to improve participants' homogeneity the proportion of male students was not similar between university. Participants were allocated conveniently into two groups based on their university, to prevent diffusion of the intervention; students from two universities were placed in the experimental group, and those from the third university into the control group. Participants in each group were also classified into two clusters by pre-test learning achievement score: the "below-mean cluster" and the "above -mean cluster." The mean was chosen as the cutoff point because it was the highest score among mean, median, and mode. As the distribution of the participants' prior knowledge showed positive skewness, the mean was higher than the median. For the even allocation of the participants, we determined that the mean was more appropriate as the cutoff point. Moreover, as a higher score is needed for medication patient safety, the higher cutoff point was adopted. Statistically, the mean contains more important information than the median or mode, is easy to understand, and representative of the data.

The sample size was calculated based on Kim, Park, and Park (2012). A power analysis for a t-test was performed using an alpha coefficient of 0.05, beta of 0.20, and effect size of 0.20. The required sample size was 199 participants. Ninety-three nursing students from two universities were recruited as the experimental group and 85 (91.4%) agreed to participate in this study. An additional 97 nursing students from another university, the control group, were recruited, and 82 (84.5%) agreed to participated. The reason for the high voluntary participation rate was considered to be because nursing students had high motivation for and interest in enhancing drug dosage calculation competence. A total of 167 participants was recruited and categorized into the four groups (**Figure 1**). Eighty-one students (95.3%) in the experimental group and 76 students (92.7%) in the control group completed the pre-and post- test. The effect size of this study was 0.46 with an alpha coefficient of 0.05, a beta of 0.20, and an input of 157 participants.

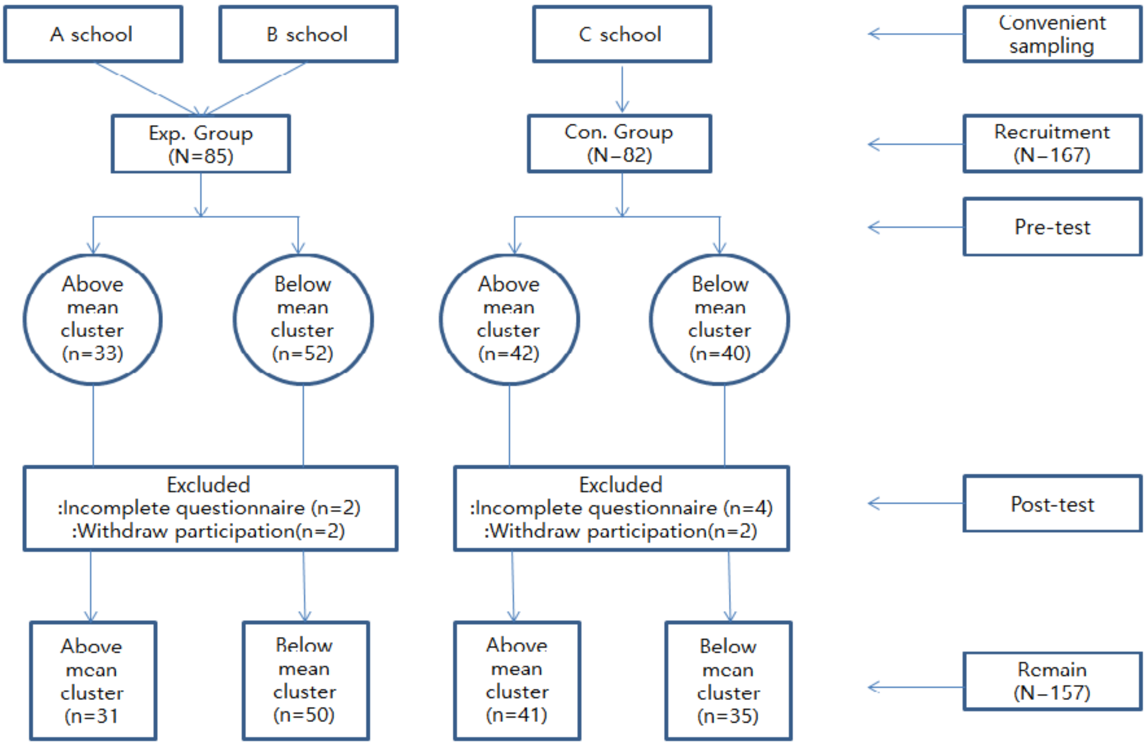

Figure 1. Flow chart for participants recruitment

Development of Intervention

The smartphone-based app for this study was developed by the research team. Analysis of learners and their environment, designs for templates and contents, program development, and evaluation by informatics experts were performed, and the effectiveness and validity were proved in a previous study (Kim et al., 2012). The smartphone-based app adopted a cognitive-load theory and contained two pages; a principle learning page and a practical game page. The former consisted of four subcategories: "metric conversion," "tablet calculation," "fluid dosage calculation," and "drop rate calculation." On this page, the participants could see the solution to the problem they were assigned and use it to comprehend the principles of dosage calculation. The latter contained three chambers, as follows: "basic," "intermediate," and "advanced." In each chamber, 15 questions were shown for each of the four subcategories. Response scores were calculated and appeared as the participants' rankings in charts. The app can provide individualized interfaces, give real-time access to information related to the use of the app and feedback, and maximize strengths as smartphone-related learning material. This app was developed to be used with both the iOS and Android operating systems; participants used it on their own smartphones.

Procedures of Intervention

Researchers developed contents and a handout for a 1 hour lecture on basic mathematics and drug dosage calculation formulas. The developed teaching materials and methods were reviewed by two experts to assess face validity and content validity, and the materials were provided to three different lecturers in each university. To ensure teaching method consistency among lecturers, two discussion times were held. In order to get reliable results, a double-blind trial was used for grouping and providing intervention. The participants were taught metric conversion, formulas for drug dosage (tablet and fluid amount), and infusion and drop rate calculation in the classroom, and after the lecture, completed the pre-test questionnaire. The available test time was 20 minutes, and the participants were allowed to use a calculator.

After the test, a smartphone app using approved login information was provided for the experimental group. In order to increase treatment fidelity, the researchers guided the participants to use the app at least once a day and, once a week, reminded them to use the app after confirming experimental group members' contact time and frequency each week. For the control groups, self-study was recommended using the handout and conventional study method during the same four-week period. Four weeks after starting the intervention, a post-test was administered to both groups, using a similar questionnaire as that used for the pre-test. With ethics in mind, the smartphone app was provided to the control group after the research period. The study was conducted from October 2012 to June 2013.

Outcome Measures

Learning achievement

In this study, learning achievement is the ability to calculate tablet count, fluid amount, and drop rates exactly. The questionnaire consists of three dimensions (tablet count, fluid amount, and drop rates) with nine items. This scale was validated by a nursing education specialist who had over 10 years of nursing experience and a doctoral degree, using CVI (content validity index); all items scored over 80 percent on validity. Coding was registered as "1" if the respondent selected the correct answer and "0" if the wrong answer. Total scores could thus range from 0 to 9, with a higher score indicating greater learning achievement. To test item difficulty, items answered correctly by more than 80% of the participants were considered too easy and items answered correctly by less than 20% of the participants were considered too difficult based on Sung (2016). The item difficulties of the 18 questions at pre- and post-test were moderate or low difficulty. The discrimination index may range from -1 to 1, which is less than .20 as "no discriminating power," .21-.40 as "having discriminating power," and more than .41 as "high discriminating power," The discrimination of the 18 questions at pre- and post-test ranged from .21 -.40. Kuder-Richardson Formula 20(KR-20) reliability ranged from.76 to .78 at pre- and post-test.

Metacognition

An instrument developed by O'Neil and Abedi (1996) and translated into Korean by Park and Kweon (2010) was used to measure metacognition in this study. It includes 20 items in four subscales: awareness (five items), cognitive strategy (five items), planning (five items), and self-checking (five items), all answered on a five-point Likert scale (from 1, strongly disagree, to 5, strongly agree), with higher scores indicating higher levels of metacognition. The construct validity of the original metacognitive inventory was acceptable (O'Neil & Abedi, 1996). Cronbach's alphas for the original community college sample were from .75 to .79 (O'Neil & Abedi, 1996) and for this study, from .76 to .87.

Flow state

In this study, we used the Flow State Scale to assess participants' degree of concentration or interest when answering calculation questionnaires. It was developed by Jackson and Marsh (1996) in a study of participants in a physical activity setting, and was adapted to answering calculation questionnaires in this study. It consists of 36 questions answered on Likert scale as above. Higher scores indicated higher concentration and higher feeling of control over drug dosage calculation performance. Cronbach's alpha coefficient was .83 in the developmental study (Jackson & Marsh, 1996) and .85 in this study.

Statistical analysis

Data were analyzed using SPSS for Windows, version 23.0 (SPSS, Chicago, IL, USA). Descriptive analyses were used to determine the characteristics of the participants. To examine the homogeneity of the general characteristics and study variables of participants, Fisher exact tests and Mann-Whitney U tests were conducted in above and below-mean clusters, because study variables did not show normal distribution. Mann-Whitney U tests were conducted to compare the differences of outcome variables (learning achievement, metacognition, and flow) between the two groups in each cluster.

Ethical consideration

Prior to data collection, approval for this study was obtained from the Institutional Review Board of our university (IRB No. 1041386-20121005-HR-011-03). During the recruitment period, the purpose, voluntary participation, confidentiality of the information, and procedures of the study were explained to nursing students in each school. Also, the students were told that the results would be considered confidential for study-related purposes and would not have influenced their training path. Written consent was obtained from all of the participants before the pretest.

Table 1. Homogeneity of General Characteristics, Learning Achievement, Metacognition, and Flow by Groups at the Baseline (N=157)

	Above-mean cluster			Below-mean cluster		
	Exp. (n=31)	Cont. (n=41)	Z(p)	Exp. (n=50)	Cont. (n=35)	Z (p)
Age	20.71±0.59	20.76±1.07	1.02(.308)	20.80±0.64	20.66±0.66	.033(.740)
Phone use time	58.58±16.37	58.76±18.71	1.33(.183)	57.32±14.28	62.29±17.09	.069(.945)
Learning achievement (9)	0.81±0.15	0.83±0.13	0.79(.428)	0.26±0.08	0.18±0.10	**4.62(<.001)**
Tablet calculation (3)	0.96±0.11	0.91±0.18	1.05(.295)	0.67±0.16	0.35±0.18	**6.58(<.001)**
Fluid amount calculation (3)	0.92±0.22	0.83±0.21	**2.59(.010)**	0.05±0.14	0.08±0.14	0.99(.332)
Drop rate calculation (3)	0.54±0.40	0.76±0.33	**2.39(.017)**	0.07±0.17	0.10±0.18	1.07(.284)
Meta cognition (20)	3.42±0.46	3.35±0.59	0.06(.954)	3.52±0.54	2.96±0.60	**3.93(<.001)**
Aware (5)	3.46±0.39	3.41±0.60	0.02(.986)	3.52±0.53	3.01±0.67	**3.49(<.001)**
Cognition (5)	3.33±0.59	3.30±0.61	0.88(.381)	3.52±0.58	2.92±0.61	**4.13(<.001)**
Planning (5)	3.60±0.51	3.40±0.68	0.03(.977)	3.64±0.58	2.89±0.65	**4.72(<.001)**
Self-checking (5)	3.30±0.58	3.29±0.62	0.77(.439)	3.41±0.62	3.01±0.63	**2.44(.015)**
Flow (36)	3.36±0.50	3.28±0.52	0.24(.811)	3.48±0.61	2.86±0.63	**4.13(<.001)**

Table 2. Group Comparisons of Learning Achievement, Metacognition, and Flow at the Post-test (N=157)

	Above-mean cluster			Below-mean cluster		
	Exp. (n=31)	Cont. (n=41)	Z(p)	Exp. (n=50)	Cont. (n=35)	Z (p)
Learning achievement (9)	0.02±0.19	-0.13±0.19	**3.16(.002)**	0.00±0.15	0.43±0.24	**-6.69(<.001)**
Tablet calculation (3)	-0.08±0.19	-0.18±0.31	1.78(.076)	-0.09±0.24	0.30±0.32	**-5.48(<.001)**
Fluid amount calculation (3)	-0.01±0.24	-0.07±0.33	0.77(.442)	0.08±0.21	0.55±0.35	**-5.92(<.001)**
Drop rate calculation (3)	0.15±0.46	-0.15±0.37	**2.76(.006)**	0.02±0.29	0.45±0.42	-4.91**(<.001)**
Meta cognition (20)	0.26±0.38	0.03±0.63	**2.50(.012)**	-0.30±0.57	0.17±0.57	**-3.31(.001)**
Aware (5)	0.28±0.51	-0.02±0.63	**2.36(.018)**	-0.25±0.58	0.09±0.61	**-2.01(.036)**
Cognition (5)	0.25±0.50	0.06±0.73	1.64(.101)	-0.34±0.68	0.18±0.67	**-3.39(.001)**
Planning (5)	0.29±0.40	0.04±0.72	**2.58(.010)**	-0.30±0.71	0.33±0.56	**-3.95(<.001)**
Self-checking (5)	0.24±0.54	0.03±0.71	**2.00(.046)**	-0.32±0.60	0.08±0.74	**-2.62(.009)**
Flow (36)	0.18±0.50	-0.03±0.69	**2.42(.016)**	-0.33±0.53	0.20±0.56	**-4.35(<.001)**

RESULTS

Homogeneity Test of Research Variables between Groups

General characteristics as potential impacting variables on prior knowledge, including age, gender, and phone use time, were homogeneous. Baseline characteristics of the participants are shown in **Table 1**. Based on the homogeneity test, there were significant differences in baseline research variables: fluid amount calculation (Z=2.59, *p*=.010) and drop rate calculation (Z=2.39, *p*=.017) in the above-mean cluster, total learning achievement (Z=4.62, *p*<.001), tablet calculation (Z=6.58, *p*<.001), metacognition (Z=3.93, *p* <.001) and flow (Z=4.13, *p*<.001) in the below-mean cluster. The participants were not homogeneous in learning achievement, metacognition, and flow.

Effects of the Intervention on Learning Achievement, Metacognition and Flow

The effects of the intervention on learning achievement, metacognition and flow are shown in **Table 2**. In the above-mean cluster, changes in total learning achievement (Z=3.16, *p*=.002) and drop rate calculation (Z=2.76, *p*=.006) in the experimental group were significantly higher than those in the control group. Total metacognition (Z=2.50, *p*=.012) including awareness (Z=2.36, *p*=.018) and planning (Z=2.58, *p*=.010) of the experimental group changed more significantly than those of the control group. Difference of the flow score (Z=2.42, *p*=.016) in the experimental group was higher than in the control group. In the below-mean cluster, changes of all outcomes variables in the experimental group were lower than in the control group.

DISCUSSION

A previous study has shown that prior knowledge can influence students' interaction with a technology-based learning environment and affect their use of self-learning strategies in it. It is also known that there are significant differences in the use of metacognitive strategies and the experience of flow between prior knowledge groups (Taub, Azevedo, Bouchet, & Khosravifar, 2014). Therefore, we assumed that not only learning achievement, but also metacognition and flow exhibited during the use of the smartphone-based training program, would vary according to the participants' prior knowledge level. We will discuss the comparison of the differences between pre- and post-tests after separating the participants by their prior knowledge level.

In the above-mean cluster, the learning achievement change between the pre- and post-tests of the experimental group was significantly higher than that of the control group. According to a previous study (Wright, 2008), the most important resource for developing drug calculation skills and abilities is regular exposure to calculation in clinical practice. In the case of nursing students, because we cannot provide a real continuous clinical environment for calculation, a virtual reality environment using a smartphone -based app will be helpful. The present results showed that the smartphone-based app was an effective supplement as a traditional pedagogical agent for learners with higher prior knowledge. Furthermore, because RNs working in a unit that rarely calculated drugs have reduced regular exposure and educational opportunities after entering practice, smartphone-based training programs are expected to be able to play a supportive role, increasing these nurses' drug dosage calculation competence.

There were significant differences in metacognition and flow according to the groups. The metacognition score change of the experimental group was higher than that of the control group, especially for awareness and planning. On the practical game page, students presumably define dosage calculation as a task they must resolve, set the goal based on their own plan and get feedback by their ranking. Repeated testing would produce metacognitive questions, such as "What do I know?", "What do I want to know?", and "What have I learned?" These questions would foster metacognitive power in the mobile learning environment. Based on the fact that the relationships between self-learning and metacognition are recursive (Cotterall & Murray, 2009), repeat use of this app tends to enhance metacognitive power, and highly metacognitive learners tend to understand and manage their learning better.

The flow state score change of the experimental group was also higher than that of the control group. To experience flow state, clear goals, loss of self-consciousness, transformation of time, and unambiguous feedback are also needed (Jackson & Marsh, 1996). In this study, the principle learning page of the app showed clear goals by presenting information on metric conversion, tablet calculation, fluid amount calculation, and drop rate calculation, while the practical game page allowed the participants in the experimental group to experience flow state via loss of self-consciousness. Learners might feel the time passing in a way different from normal, caused by various interactions between technology and user. When actively participating using this page, learners were expected to be motivated by its imagery and auditory feedback, reinforcing their flow state more than that of the control group. Similar to previous work (Hung et al., 2015), it is concluded that game-based learning promoted flow state in this study.

In the below-mean cluster, there were also significant differences in total learning achievement and in subcategories including tablet count, fluid amount, and drop rate calculation. However, the differences of learning achievement in the experimental group were lower than those in the control group. These results are not consistent with those of previous studies. All kinds of educational strategies including classroom teaching were at least somewhat effective (Härkänen, Voutilaine, Turunen, & Vehviläinen-Julkunen, 2016); in particular, the use of simulation in medication calculation has shown positive significant effects on mathematical ability (Grugnetti, Bagnasco, Rosa, & Sasso, 2014). Two possible explanations for these results present themselves: 1) lack of prior knowledge and 2) failure to control learning speed. That is, if learners have a schema related to prior knowledge, that schema will be activated automatically, reducing cognitive load and promoting problem -solving, when the learners encounter new information (Byun, Ryu, & Song, 2011). Learners in the experimental group presumably feel more awkward using the smartphone-based application and calculation questionnaire than do those in the control group; as a result, they may fail to properly control learning speed and may feel more of a cognitive load. In addition, due to these frustrations, learners in the experimental group may stop studying, while the control group continues to use the training book.

A smartphone-based training program itself is not effective for learners' metacognition and flow, even though smartphone-based apps are regarded as a supportive tool for enhancing metacognitive power (Lee, 2013) and flow (Lee & Lee, 2013). We provided a "worked example effect" showing an instructional example of the solution to the problem; this might improve metacognition. Game-based learning content and interactivity help learners concentrate, which is strongly related to the experience of flow (Hung et al., 2015). However, smartphone-based training program usage showed no effect on learners with low prior knowledge. Two explanations might exist.

First, it could be elicited more slowly in participants with poor prior knowledge, due to their lower learning competence using the application. Therefore, until their knowledge schema settles down more concretely (Byun et al., 2011), it might be difficult to rapidly improve their metacognition and flow. Second, as previously written, because learning activities and metacognition are recursive traits (Cotterall & Murray, 2009), unchanged metacognition may become a barrier to improving learning activities and learning achievement, and perhaps also vice versa. To address this, re-verification needs to be performed in a replication study with longer intervention time and more participants.

This study has yielded useful data on the effectiveness of smartphone based training combined with prior knowledge, but it also has some limitations that should be registered. First, this study was not randomized; instead, convenience sampling was used because of the difficulty of obtaining consent from the nursing schools involved. Heterogeneously made teams can foster communication and other social skills such as problem solving and critical thinking (Schmidt, 2007), leading to collaborative study and interactive relationships. Thus, this research should be repeated using this application but with random assignment of participants should be done.

CONCLUSIONS

Effects of the application on learning achievement, metacognition, and flow differed by users' prior knowledge level. Specifically, smartphone-based app users in the higher-prior-knowledge group felt more concentration and interest in dosage calculation and gained better results for learning achievement, metacognition, and flow. For learners with lower prior knowledge, additional instructional design or implementation strategies for enhancing the learning outcomes should be prepared.

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Investigation of Learning Behaviors and Achievement of Simple Pendulum for Vocational High School Students with Ubiquitous-Physics App

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ABSTRACT

In this study, Ubiquitous-Physics was designed and proposed for facilitating students to learn simple pendulum concepts. U-Physics can facilitate collecting experimental data and drawing the corresponding graphs during the experiment, whereby students can focus on how to interpret graphs and solve problems through applying formulas. The participants were second grade female vocational high school students who are fewer interests in physics, while hopefully using U-Physics in the physical experiment can motivate their interests and help their learning in physics. The findings showed that significant correlations existed among hypothesis-making, interpreting graphs, applying formulas, conclusion-making, conceptual understanding, and post-test. After an in-depth investigation, we found that interpreting graphs and conceptual understanding were the two most important factors to affect learning achievement. Additionally, students perceived that U-Physics was beneficial to their physics learning.

Keywords: applying formulas, conceptual understanding, hypothesis-making, interpreting graphs, Ubiquitous Physics (U-Physics)

INTRODUCTION

Learners need to use critical thinking to create great articulations and summary on explaining their answers when they learn physics. In practices, learners not only need to understand physics principle and calculation but also cultivate how to improve crucial thinking and reasoning adequately. Representation abilities of learners' were shown to help critical thinking and problem solving (Leslie, Low, Jin, & Sweller, 2012; Mayer, 1992; Nievelstein, Van Gog, Van Dijck, & Boshuizen, 2013; Stylianou & Silver, 2004; Sullivan & Puntambekar, 2015). Learners need to explore and discover unique examples or principles inside the issues, and then utilize representations to clarify comparable issues with different structures or viewpoints in the process of applying formulas. Regardless, a few studies claimed that most learners neglect to understand the essentialness of relationship between different types of representations (Ainsworth, 1999; Kalyuga, Chandler, & Sweller, 2000).

A successful of physics learning cannot be separated from students' learning behaviors while they are doing physics experiment. Teachers can study students' learning behaviors to know whether students pay attention, understand concepts and procedural instructions and measure the results of the experiment. Making hypothesis/assumptions is an important aspect of the testing experiment and a vital step in solving daily physics phenomena and need to be developed to support students' physics learning (Etkina, Murthy, & Zou, 2006; Fortus, 2009). Hypothesis-making is students' prediction before experimenting. We assumed that hypothesis-making would affect students' learning achievement.

Graphs could be utilized to help physics and mathematics learning (Supalo, Humphrey, Mallouk, Wohlers, & Carlsen, 2016; Zebehazy & Wilton, 2014). The ability to interpret, recognize, understand, and work with graphs involves mathematical skills and processes (Friel, Curcio, & Bright, 2001). This ability called interpreting graphs knowledge which can be very helpful before, during, and after physics experiment. However, recently, information

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Contribution of this paper to the literature

- Interpreting graphs played a critical role in a physics experiment, so we strongly suggest experimental procedure should ask learners to interpret physics phenomena by graphs.
- U-Physics is not only an excellent tool to measure the period of pendulum more accurately by providing interpreting graphs rather than a traditional tool but also can link students' concept and experiment measurement in a lab.
- U-Physics using the sensors of Tablet PC's with multi-representation can facilitate teachers and students not only to build physics phenomena but also to organize and manipulate sampling data for in-depth analysis.

or content of knowledge is not often expressed using graph representations and pictures in mathematics, engineering and science (Zebehazy & Wilton, 2014).

In a physics experiment, applying formulas and calculation processes are a part of physics language. The mathematical expression and processes are used to incorporate or deliver critical components of content; most physicists read a formula in composed writings and expressed it into physical notions. The ability to apply and calculate formulas in physics learning can improve students' concepts and knowledge through applying what they discovered in authentic context as well as scientifically communicating with others (Lin, Liang, & Tsai, 2015). It is essential for students not only to comprehend physical and mathematical concepts independently but also understand the correlation between physical and mathematical for active learning (Greca & de Ataíde, 2017).

Students must conclude and decide to reject or accept hypotheses from data gathered (De Jong, 2006) after experimenting. This conclusion-making is students' ability to conclude their experiment result, and it might be helpful for constructing or reconstructing their hypothesis.

Based on above mentioned, we considered that these five students' behaviors included hypothesis-making, interpreting graphs, applying formulas, conclusion-making, and conceptual understanding is associated with students' learning achievement. Therefore, we experimented with vocational high school students and designed a U-Physics mobile app to facilitate students learn simple pendulum concepts. Besides, we studied the five learning behaviors and its relation to learning achievement. This study also investigated students' perception towards U-Physics app in learning simple pendulum for helping the further improvement of our activity and app designs.

LITERATURE REVIEW

Representation to Facilitate Scientific Learning

Representations have various meanings. For instance, it can be a configuration of concrete objects, images, or character which can represent something else (DeWindt-King & Goldin, 2003). Arithmetic, language, and graph belong to representation (Hwang, Chen, Dung, & Yang, 2007). Commonly, arithmetic symbol, language, authentic object, concrete, and graphic representations are used in Mathematics learning (Lesh, Post, & Behr, 1987). The language, arithmetic symbol, and graphics are the most important and abstract for mathematical problem solving (Lesh et al., 1987; Milrad, 2002; Zhang, 1997).

Students with good problem-solving skills are those who are also good at manipulating and using language, graphs, and arithmetic representations. In contrast, students with low problem-solving skills are difficult to represent and translate an observed object. Therefore, teachers should acquire various teaching strategies to encourage students to use multi-representation in class, and learning achievement should then be enhanced (Cai & Hwang, 2002).

The correct use of representation is crucial and considered a key to physics learning. Students' representation abilities in physics learning can help teachers to understand how well their students interpret and solve physics phenomena. Besides, teachers also can know whether students understand physics concepts profoundly or not through their representation skills (Kohl, Rosengrant, & Finkelstein, 2007). So in this study, we would ask students to use various representations to learn simple pendulum. Students need to find some clues to solve related physics problems with hypothesis making, applying formulas, and graphs explaining supported by U-Physics.

Authentic Learning

A familiar authentic surrounding creates advantages to help comprehension and application of new cognition. A study demonstrated that daily life problems in the authentic scenario were related to language acquisition (Hwang, Chen, Shadiev, Huang, & Chen, 2014). The authentic context is a critical prerequisite for active learning (Kiernan & Aizawa, 2004). Authentic learning can provide contexts that reflect the way in which the knowledge will be used in real life and promote reflection. Authentic learning also should provide activities that have daily life relevance and offer authentic within-task learning assessment. Furthermore, authentic context should be able to create a chance for learners to share learning experiences and enables learners with different levels of expertise to practice (Hwang, Huang, Shadiev, Wu, & Chen, 2014).

A study claimed that authentic environment was useful for learning (Hwang, Chen, et al., 2014). It is similar with the cultural schema theory (Nishida, 2005), which mentioned that the knowledge and pre-knowledge together arise when observing familiar authentic environments. The study also argued that the schema was created based on the information from our environment and saved it in the brain. The environment becomes familiar after we enter repeatedly. The saved schema guides and helps us to predict what is to be expected and looked for in a familiar environment.

One of the advantages of mobile technology in learning is to offer seamless learning. Mobile technology can be used anytime and anywhere to facilitate students' learning (Kim, Suh, & Song, 2015). It may also create an authentic learning environment within a familiar context rich in resources for learning (Kim & Kim, 2012). Furthermore, mobile technology can be used for formal and informal learning (Wang, Wu, & Hsu, 2017).

Multimedia such as image, audio, and text generated by learners through mobile technology can make learning more meaningful and interesting, particularly using media in an authentic environment. The use of image and audio in authentic contexts can also make learning more interactive, productive and engaging (Golonka, Bowles, Frank, Richardson, & Freynik, 2014). In addition, studies shown that multimedia such as graphs and text annotations and the sensor technology of mobile devices could help students in exploring and applying their knowledge through laboratory activities (Purba & Hwang, 2017a, 2017b).

Learning Behaviors in Scientific Learning

Learning is a process of relatively permanent change in behaviors created by experience and practice in an environment. A study demonstrated that general knowledge and behavioral were critical indicators of students' learning achievement (McLeod & Kaiser, 2004). The education literature also indicated that students' learning behaviors influenced the learning process. For instance, one of the ways to promote a more informal approach to students' learning behaviors is to utilize a social media such as Line, Facebook, and so on during their learning process (Dabbagh & Kitsantas, 2012).

Students' learning behaviors in physics can help teachers to know whether students focus, understand concepts, are aware of procedural instructions and measure the proper outcome of an experiment. Students learning can be improved by providing learning guidance and instruction after we analyzed students' behaviors.

Hypothesis-making

Hypothesis making is an essential step in solving daily physics phenomena and needs to be developed to support students' physics learning (Fortus, 2009). The hypothesis is a tentative specification of the effect of the input variables on the output variables. The hypothesis is can also have the form of a model or part of the model (De Jong, 2006). There are two approaches to generate a hypothesis; one is from theory, and the other is from data (from running experiments) (Klahr & Dunbar, 1988). The hypothesis could be an explanation of a pattern within the data and an exploration of relationship between variables (Etkina et al., 2006). Hypothesizing an experiment is one of the crucial factors of designing a test experiment. At the end of their experiment process, students have to accept or reject their hypothesis based on their findings.

Interpreting graphs

A study stated that graphs and its interpretations are the heart of science. Interpreting graphs are very crucial because it is a part of experimentation (McKenzie & Padilla, 1986). The interpreting ability is an essential requirement for expertise in problem-solving (Larkin & Reif, 1979). Researchers showed that graphs could be utilized to help physics and mathematics learning (Supalo et al., 2016; Zebehazy & Wilton, 2014). The ability to interpret, recognize, and work with graphs involves mathematical skill and processes (Friel et al., 2001). It can be useful in experiment process. Students can extract most of their information content using graphs (Beichner, 1994). Besides, interpreting graphs can help improve better conceptual understanding (Lingefjärd & Farahani, 2017). However, information or content of knowledge is not often expressed using graph representations and pictures in mathematics, engineering and also science (Zebehazy & Wilton, 2014). Therefore, in this study, we encouraged students to interpret graph based on their experiment findings through our developed app, U-Physics.

Applying formulas

Physics language cannot be isolated from mathematical expression. The mathematical expression and processes are used to incorporate or deliver critical components of content; most physicists read a formula in a composed writings and expressed it into physical notions. The ability to apply and calculate formulas in physics learning can improve students' concepts and knowledge through applying what they discovered in authentic contexts as well as scientifically communicating with others (Lin et al., 2015). The understanding of utilizing of physics formulas can significantly express students' concepts of the learning materials (Sherin, 2001). The arrangement of symbols in physics formulas represent a meaning that can be understood by learners. Students understanding of what the formulas say in essential meanings could lead and guide their works. In this study, we ask students not only to use symbolic expressions but also understand the meaning of symbolic expressions and its manipulations.

Conclusion-making

Conclusion-making is students' ability to conclude their experiment result, and it might be helpful for constructing or reconstructing their hypothesis. In a physics experiment, learners must conclude and decide to reject or accept hypotheses from data gathered (De Jong, 2006). In other words, after doing experiment students need to conclude what they found from data gathered. This conclusion is a way to confirm their previous hypothesis. It shows that hypothesis-making correlated to conclusion-making.

Conceptual understanding

Conceptual understanding of physics is necessary for learning and becomes a critical part of solving problems related to physics phenomena. It is crucial for students to understand not only physics concepts and mathematics concepts separately but also relationships between physics and mathematics concepts in creating efficient learning (Greca & de Ataíde, 2017). Besides, Conceptual understanding is students' ability to summarize and construct or reconstruct their concept of learning material. To lead students' conceptual understanding effective physics instruction must encourage the kind of learning. Many researchers claimed that an experience that leads students to evaluate their conception and be encouraged to develop a better replacement on their perspective could build students' scientific conception (Duschl & Gitomer, 1991; Dykstra, Boyle, & Monarch, 1992; Posner, Strike, Hewson, & Gertzog, 1982). In this study, conceptual understanding is students' thinking and ideas about the meaning and content of science concepts. Students' conceptual understanding could be promoted by allowing students to explore science phenomena with a computer or mobile app in their surroundings (Lee, Nicoll, & Brooks, 2004; McElhaney, Chang, Chiu, & Linn, 2015; Wang et al., 2017).

Based on above mentioned, we considered that these five students' behaviors included hypothesis-making, interpreting graphs, applying formulas, conclusion-making, and conceptual understanding is associated with students' learning achievement.

UBIQUITOUS-PHYSICS (U-PHYSICS)

We developed a Ubiquitous-Physics (U-Physics) mobile app to help and facilitate students learn simple pendulum concepts in physics class. The U-Physics app works on tablet PC or smartphones. The app utilized an acceleration sensor of the tablet to collect acceleration and velocity values. Those values are transformed into a graph and used to facilitate students' understanding of the pendulum period time. In the current study, we focused on three different experiment about the simple pendulum. The first experiment aims to help students learn the effect of pendulums' mass concerning it swing period. The second experiment aims to help students learn the effect of pendulums' length concerning it swing period. The last experiment is to help students learn the effect of pendulums' angle or inclination concerning it swing period. Three different leading questions and learning materials were installed in U-Physics. In addition, U-Physics also provides annotation function to help students interpret and explain their understanding of simple pendulum concepts easily.

Three main functions work in U-Physics. The first function is a general function. This function aims to start, stop, open the leading questions, screenshot a graph, and open the gallery files. Those are shown in button 1, 2, 9, 10, and 15 of **Figure 1**, respectively. The second function is interpreting graphs function. This function is to show several graphs based on different axes and values. Acceleration sensor inside the tablet collects those graphs values. The button function is shown in button three until button 8. Students were asked to select one of the graphs and interpret it. The last function is annotation function and shown in button 11 to 14 (**Figure 1** and **2**). Studied can edit their graphs functions in button 11 to 13 after experimenting. Then students need to complete their results by writing and putting the evidence and conclusions in function 14 layout.

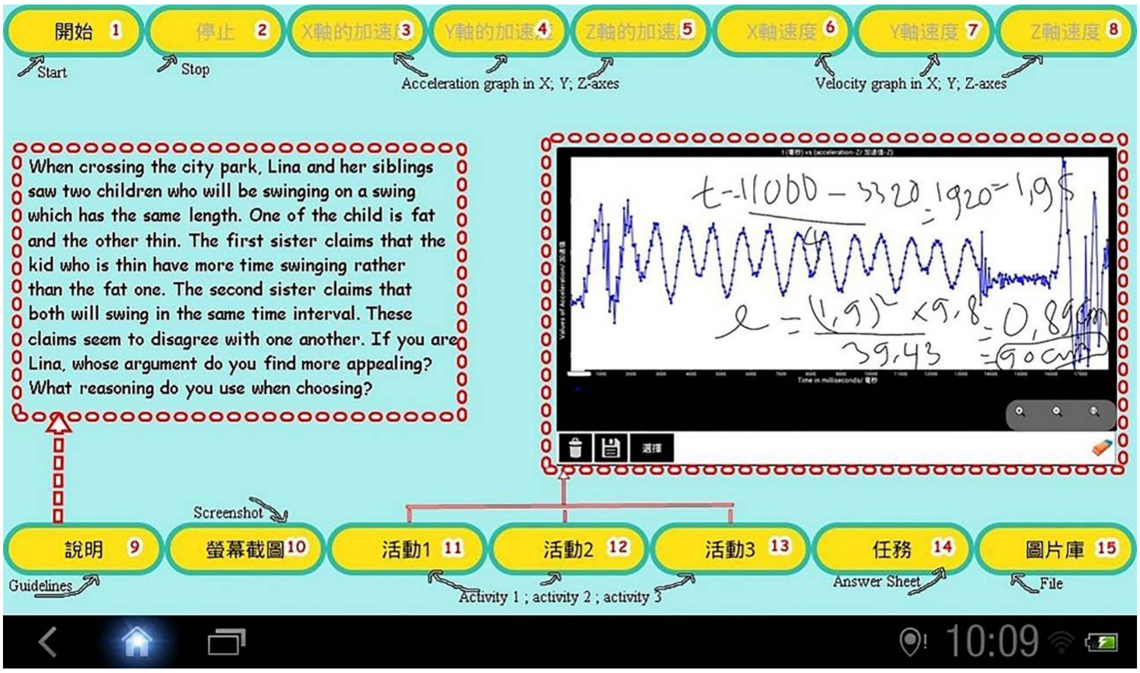


Figure 1. U-Physics user interface including guidelines and activities

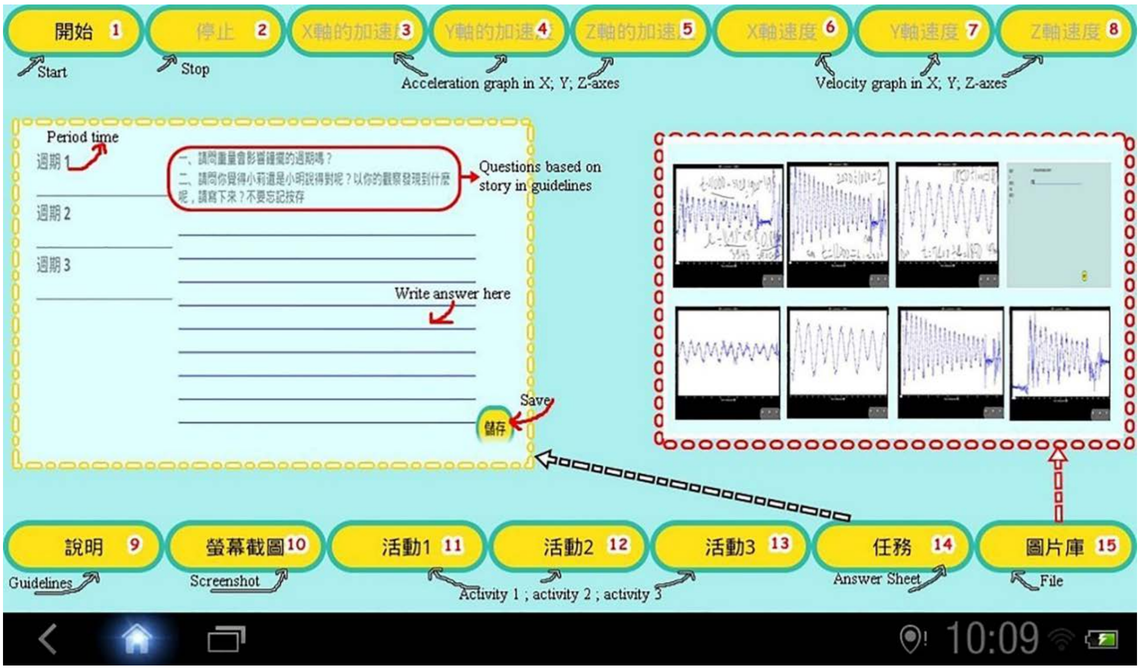


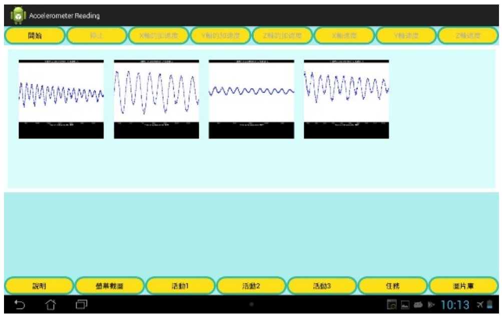
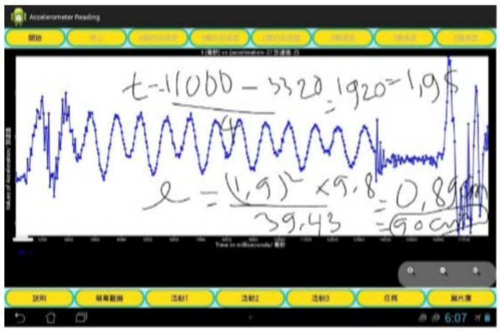
Figure 2. U-Physics user interface including answer sheet and file

METHODOLOGY

Participant

Sixty-six female students of the second-grade vocational high school participated in the experiment. Their ages were around sixteen to seventeen. Moreover their major is related to applied science, so they seldom do such kind of physics experiment during their vocational high school study. An experienced physics teacher taught the two groups with the same learning material about simple pendulum concept. The learning materials of the two groups were designed based on a school textbook. In this study, there were three different experiment we were conducted: (1) different mass; (2) different length; and (3) different angle. Demographic results also showed that most of the

Table 1. Learning behaviors and learning achievement marking criteria

Variables	Items		Score	Example
Hypothesis making	The correct answer to One Yes/No question		5 points	Question: *Box A and B have the same weight. Both boxes will swing independently from the same angle. Box A have a longer rope than box B. Therefore, box A has a longer time than box B (Yes/No).* Answer: *Yes, box A will have a longer period than box B.* (The score of this student answer was **5 points** because the response to the statement was correct but no explanation about the reason behind)
	Incorrect or without an answer of One Yes/No question		0	
	The correct answer for the reasons		5 points	
	Incorrect or without an answer of the reasons		0	
Interpreting graphs	Quantity	> 9 trials	4 points	 (This picture is an example of data collection of a quantity of graph interpreting. Because we only found four different graphs in this student's file, we gave her **2 points**)
		7-9 trials	3 points	
		4-6 trials	2 points	
		1-3 trials	1 point	
	Quality	The calculation process is correct.	2 points	 (This picture is an example of data collection of quality of interpreting graphs. Because the calculation of period and the length of rope was correct and the value of length was same with the actual length of rope, we gave student **2 points**)
		The calculation process is incorrect or blank.	0	

students (55 students) have fewer interests in learning physics because physics is not their major. Experimental class (N = 32) and control class (N = 34) were randomly divided into pairs, respectively. Each pair in experimental class used our proposed app, U-Physics, in tablet PC. While in control class, each pair had a stopwatch app on their smartphone/ tablet PC.

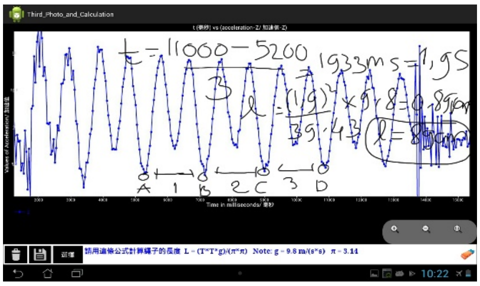
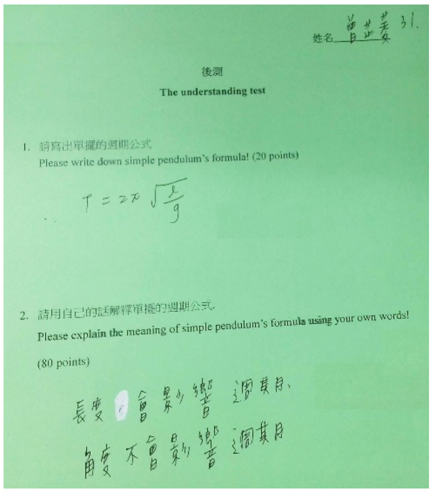
Purpose

We aimed to study the five learning behaviors and their relation to learning achievement of vocational students. Three research questions are specified as follows:

1) Does experimental group perform better than a control group on learning achievement?
2) What is the relationship among learning behaviors variables such as hypothesis-making, interpreting graphs, applying formulas, conclusion-making, conceptual understanding and their effects on learning achievement (Post-test)?
3) What is students' perception of U-Physics app?

Hypothesis-making, interpreting graphs, applying formulas, conclusion-making, and conceptual understanding belong to learning behaviors factors. The post-test belongs to learning achievement factor. An experienced Physics teacher evaluated the marking criteria. **Table 1** shows the marking criteria of each variable and its definition as described below:

Table 1 (continued). Learning behaviors and learning achievement marking criteria

Variables	Items		Score	Example
Applying formulas	Item 1	The calculation process is correct.	5 points	 (We picked up an example of applying formulas as the picture above. Student calculation process was correct, so we gave student **5 points**. In applying formulas, there were four items entirely)
		The calculation process is incorrect or blank.	0	
	Item 2	The calculation process is correct.	5 points	
		The calculation process is incorrect or blank.	0	
	Item 3	The calculation process is correct.	5 points	
		The calculation process is incorrect or blank.	0	
	Item 4	The calculation process is correct.	5 points	
		The calculation process is incorrect or blank.	0	
Conclusion making	The correct answer to One Yes/No question		5 points	Question: *Box A and B have the same weight. Both boxes will swing independently from the same angle. Box A have a longer rope than box B. Therefore, box A has a longer time than box B (Yes/No).* Answer: *Yes, box A will have a longer period than box B. This is because box A has a longer rope than box B. The period is proportional to the length of the rope.* (The score of this student answer was **10 points** because the response to the statement was correct as well as the reason)
	Incorrect or without an answer of One Yes/No question		0	
	The correct answer for the reasons		5 points	
	Incorrect or without an answer of the reasons		0	
Conceptual understanding	Write down simple pendulum formula	Correct	2 points	 (The first question, her answer was correct, so we gave **2 points**. The second question, her response is the period of pendulum only depends on the length of the pendulum. The other factors such as the angle and weight of pendulum will not affect the period. These statements are correct, so we gave **3 points**. So the total score of conceptual understanding for her was **5 points**.)
		Incorrect	0	
	Explanation of simple pendulum formula	The correct definition of Simple pendulum variables only	2 points	
		The incorrect or without a definition of Simple pendulum variables only	0	
		The correct correlation among simple pendulum variables	3 points	
		The incorrect or without correlation among simple pendulum variables	0	
		The correct examples to support the definition	3 points	
		The incorrect or without examples to support the definition	0	
Pre-test or Post test	8 Multiple choice questions	Correct	5 points/ each item (The total score for multiple choice is 40 points)	For the example of pretest and posttest please refers to Figure 3.
		Incorrect/blank answer	0	
	1 Essay question	There were three answers to the essay. Each answer will get 20 points, and the total score for the essay is 60 points.	Correct: 20 points/ answer	
			In correct/blank answer: 0	

Hypothesis making is students' ability to predict the possibility of experiments' results before an experiment. Each experiment has the questions of hypothesis-making. If the answer and reason are correct, we gave 10 points. If students only have the right answer or reason, we gave 5 points. We gave 0 point if students' answer and reason are incorrect. . We gave the equal points for a correct answer and reason because the physics teacher and researchers thought we should appreciate equally their efforts to answer this question no matter it was guessed only. Since they are seldom done physics experiments in vocational high school, and their majors are not science, so we decided to give 5 points equally for a correct answer and reason.

Interpreting graphs are students' ability to interpret their graphs and find the period correctly. The interpreting graphs were evaluated into two aspects, quantity and quality. The different mass, length, and angle were divided into three kinds of mass (the first mass, the second mass, and the third mass); length (the first length, the second length, and the third length); and angle (the first angle, the second angle, and the third angle) respectively. So there are nine sub-experiments in total. In each sub-experiment students should experiment in three times. It means every time students experiment they collect graphs as well. The quantity of interpreting graphs were evaluated based on how many times they do an experiment and collect the graphs. Each graph has one point. In summary, students can get nine points totally for nine times doing sub-experiment in an experiment. In case students are diligent and do the experiment more than nine times, we gave them extra points. We appreciated the students' efforts to repeat the experiment more than our expectation to sharpen their understanding of the topic. The quality of interpreting graphs were evaluated based on the interpreting process and annotation in the graphs. The maximum scores are six points in an experiment. For example, different length experiment divided into the first length, second length, and third lengths. The first length experiment would have two points if students marked and selected period correctly as well as the second and third length experiments.

Applying formulas are the ability to use a formula and calculate the length of the period time. The maximum scores are twenty points in an experiment. Students were asked to select four graphs out of their findings and calculate it. For example, concerning the different length experiment, we gave five points for a graph, if students calculated the period time and the length of rope correctly.

Conclusion making is students' ability to conclude the experiment result. Conclusion making is a way to reject or accept their previous hypothesis making based on the gathered data. Conclusion making criteria are similar to hypothesis making ones.

Conceptual understanding is students' ability to summarize and construct or reconstruct their concept of learning material. In this study, we used one conceptual test to measure their conceptual understanding of the simple pendulum phenomenon. Researcher and teacher developed and designed the test content together. We gave this test to students at the end of all experiments. The conceptual understanding criteria divided into two questions. The first question is to write down a simple pendulum formula, and the correct formula has two points. The second question is to explain the meaning of the formula. If students wrote the explanation of formula's variables correctly, they got two points. If students wrote the correlation among the formula's variables correctly, they got three points. Moreover, if students wrote the example of a simple formula to support their definition successfully, they got three points more. So there are ten points in total for conceptual understanding.

Pre-test had eight multiple choice questions and one open-ended question as well as in post-test. The correct answer to each multiple choice is five points, and the correct answer to an open-ended question is sixty points. The open-ended question has three answers; therefore each answer has twenty points. In summary, the maximum scores of pre-test are a hundred points as well as in post-test.

Instrument and Tool

Pre-test and post-test

We asked students to complete eight multiple choice questions and an open-ended question in the pre-test and post-test section. The questions related to their learning activities such as hypothesis-making, interpreting graphs, applying formulas, conclusion-making, and conceptual understanding. Both tests are similar to each other (**Figure 3**).

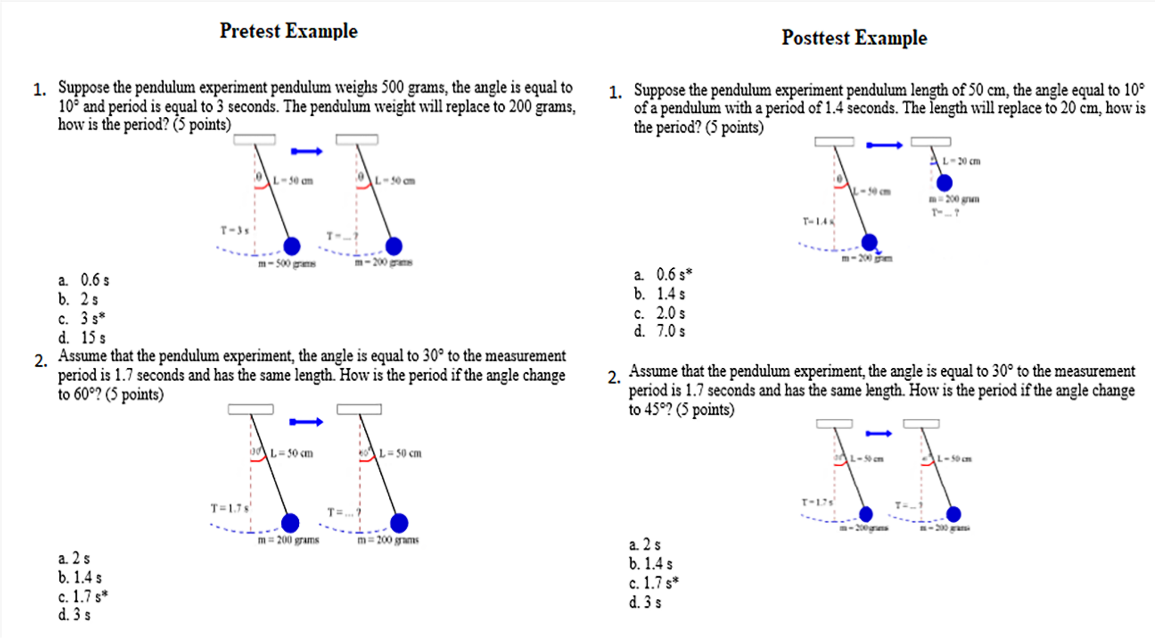


Figure 3. Pre-test and post-test example

TAM questionnaire

Technology Acceptance Model (TAM) was originated by Davis in 1989 to explain and predict the individual's acceptance of information technology (IT). TAM is extensively applied to investigate how attitudes and beliefs toward using specific information app influencing the behavioral intention and therefore actual app use. As new types of cyber medium rapidly emerged, TAM has been validated by many researchers and has become a robust theoretical model.

Students' perception towards U-Physics were evaluated by collecting TAM questionnaire responses. TAM divided into four dimensions: (1) perceived ease of use; (2) perceived usefulness; (3) intention to use; and (4) students' attitude of an app (Chung & Tan, 2004). Many researchers have employed the TAM questionnaire in their studies (Hwang, Huang, et al., 2014; Purba & Hwang, 2017a, 2017b). Therefore, we used these four dimensions and generated into fourteen questionnaire items with a seven-point Likers scale. We interviewed six students randomly to support our findings.

Material and procedure

We used U-Physics app to help students learn and understand a period of the simple pendulum. Three different experiments were conducted in this study. The first experiment aims to learn the effect of pendulums' mass concerning its swing period. We asked students to swing three different masses, a tablet, two tablets, and three tablets, respectively. Students swing and stop it after swinging back and forth seven times. Then they study their saved graph generated by U-Physics. We expected students could conclude a right conclusion and understand that mass would not affect the period time of simple pendulum at the end of the experiment. The second experiment aims to learn the effect of pendulums' length concerning its swing period. Students were asked to change three different lengths, 40 cm, 70 cm, and 90 cm, respectively. We expected students could conclude a right conclusion and understand that length would affect the period time of simple pendulum at the end of the experiment. The last experiment is to learn the effect of pendulums' angle or inclination concerning its swing period. Students were asked to change three different angles, 15 degrees, 30 degrees, and 45 degrees, respectively. We expected students could conclude a right conclusion and understand that angle is less than or equal to 15 degrees would not affect the period time of the simple pendulum and angle is greater than 15 degrees would affect the period time of the simple pendulum.

In each experiment, there were several tasks need to complete. For instance, hypothesis-making, collecting and interpreting graphs, applying formulas, conclusion-making, and conceptual understanding test. The overall research procedures were presented in **Figure 4**.

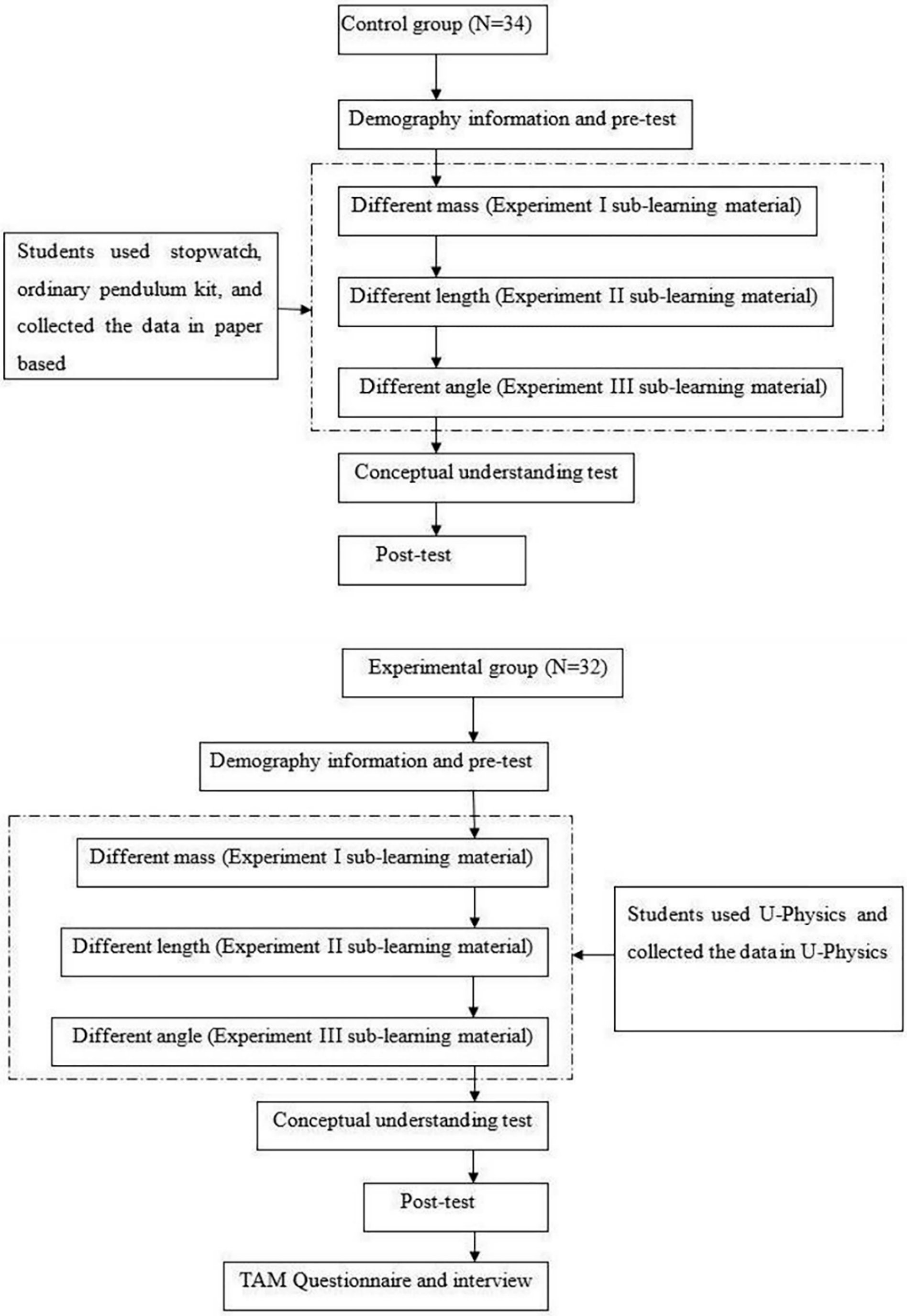


Figure 4. Research procedure

Doing a simple pendulum experiment for three weeks and remains for collecting demographic information, pre-test, conceptual understanding, post-test, questionnaire, an interview. Students were given an hour to complete experiment activities at each meeting. We randomly selected eight experimental group students to take the interview. The interview questions were described as below:

1. Did you interact with your partner during experiment activity?
2. Which part of experimental activity did you spend more time than others?
3. How did you solve the problem if you have different opinions with your partner during the experimental activity?
4. Did you understand the meaning of the formula and how to use it?

Table 2. The result of the pre-test and post-test and analysis of independent samples

Groups	Pretest				Post-test			
	Independent samples test				Independent samples test			
	Mean	SD	t	Sig.(2-tailed)	Mean	SD	t	Sig.(2-tailed)
Control	35.88	13.51			41.47	22.44		
Experiment	35.93	11.87	0.18	0.986	76.87	14.90	7.49	< 0.001

5. Did you think an hour is enough for you to conduct the experiment and learn the simple pendulum phenomena?
6. If the teacher allows you to bring the tablet back, what will you do?

Data Analysis

In this study, Pearson correlation was employed to explore relationships between students learning behaviors and learning achievement. A t-test was used to analyze comparison between students' post-test and pre-test in both groups. Finally, we used means comparison for analyzing of TAM questionnaire.

RESULTS AND DISCUSSION

The results and discussion were divided into three sections. The first section is to show and discuss any difference between students who used the U-Physics and who did not. The second section is to show and describe any relationships among hypothesis-making, interpreting graphs, applying formulas, conclusion-making, conceptual understanding, and learning achievement. The last is to study students' perception and opinion of our developed app and activity designs.

Analysis of Learning Effect

We conducted a pre-test to see whether both groups are different or not in prior knowledge. The means and standard deviations of the pre-test scores for the experimental and control groups were 35.93 and 11.87 and 35.88 and 13.51 respectively. The results showed that no significant difference between both groups in prior knowledge (t =0. 77 and p =0. 98). The results of post-test scores in **Table 2** showed that experimental students outperformed than control students on learning achievement (t=7. 49 and p<. 001). It implied that the U-Physics app was beneficial for improving student learning achievement rather than a traditional stopwatch.

It showed that U-Physics was beneficial to students' learning. U-Physics can help students to learn simple pendulum because it uses a sensor of tablet PC to collect acceleration and velocity data during pendulum swinging (Purba & Hwang, 2017a, 2017b). The accuracy of recording time based on pendulum acceleration and velocity more accurate than a stopwatch observing. Data collection was transformed into graphs synchronously by U-Physics. Therefore, students who use the U-Physics could understand the simple pendulum concept and solve related problems better than those students who used a stopwatch. In addition, U-Physics allowed students to annotate texts in their graphs. Text annotations represent students' understanding and reflection of what they learned. Text annotations could help students to interpret and understand the simple pendulum concepts in their own words. This finding indicated that text annotations have important roles in student learning achievement (Hwang, Chen, Shadiev, & Li, 2011). Therefore, we suggest that teacher may encourage students to interpret more their findings by text annotations. The graphs and text annotations could facilitate students in exploring and applying their knowledge, intensely in a profoundly authentic problem (Golonka et al., 2014; Hwang et al., 2011; Purba & Hwang, 2017a, 2017b).

Furthermore, the interview responses indicated that by experimenting with U-Physics app, most students did not only know the meaning of the simple pendulum formula but also understand the concepts and phenomena of a simple pendulum. It showed that U-Physics could facilitate students to know and understand more about simple pendulum problems. By practice simple pendulum phenomena in real experience, students use their skills repeatedly and regularly to improve and master them (Huffaker, 2004).

Analysis of Relationship between Research Variables and Post-Test

According to **Table 3**, the interpreting graphs positively correlated with applying formulas (r =. 391, p =. 027), conclusion-making (r =. 587, p =. 000), conceptual understanding (r =. 615, p =. 000), and post-test (r =. 450, p =. 010). The conceptual-understanding positively correlated with applying formulas (r =. 560, p =. 001) and the hypothesis-making negatively correlated with the conclusions making (r =-. 462, p =. 008).

Table 3. Pearson correlation between research variables and post-test in the experiment group

	Hypothesis making	Interpreting graphs	Applying formulas	Conclusion making	Conceptual Under standing	Post test
Hypothesis making	-	-	-	-	-	-
Interpreting graphs	-	-	-	-	-	-
Conclusion making	-.462**	.587**	-	-	-	-
	.008	.000				
Applying formulas	-	.391*	-	-	-	-
		.027				
Conceptual Understanding	-	.615**	.560**	-	-	-
		.000	.001			
Posttest	-	.450**	-	-	.762**	-
		.010			.000	

The significant correlation between interpreting graphs and applying formulas implied that students who interpret the graphs correctly also tended to apply the correct formula. The interpreting graphs are a key to lead students to understand the simple pendulum concepts, so students need to pay more time and attention to it. Students could know how to apply and use the formula correctly when they have a good understanding of graphs. Students who interpret the graphs should understand where the data came from by integrating the formula. It means the students' ability to understand and work with graphs representations involves calculation processes (Friel et al., 2001).

The interpreting graphs correlated to conclusion-making illustrated that students who make a correct interpretation of graphs also make the correct conclusions. Students spent more time to understand and explain the graphs. The graphs represent the experimental result. Graphs understanding means understand experiment results; therefore, students conclude the experiment readily. Besides, the interpreting graphs could also be used to explain physics phenomena to students (Supalo et al., 2016; Zebehazy & Wilton, 2014).

The correlation between interpreting graphs and conceptual understanding represented that students who are competent in interpreting graphs also are excellent in conceptual understanding. It is critical for students not only able to interpret the graphs, but also able to understand the simple pendulum concepts.

The interpreting graphs not only correlated to applying formulas, conclusion- making, and conceptual understanding but also correlated to learning achievement. It indicated that interpreting graphs play an important role in affecting other learning behaviors and learning achievement. It noted that students' mathematical pattern ability and explanation of the solution by verbal writing ability could help students' learning achievement. It also indicated that students' conceptual understanding could be promoted by allowing students to explore science phenomena with a computer or mobile app in their surroundings (Lee et al., 2004; McElhaney et al., 2015; Wang et al., 2017).

The significant correlation between applying formulas and conceptual understanding indicated that students who apply formula correctly also tended to have higher scores in conceptual understanding. By applying the formulas correctly and doing more practice, students' concepts and understandings about the formula also increase. Students not only know how to use the formula but also understand the meaning of the formula deeply at the end. It is consistent with Sherin (2001), the understanding of the formula can greatly surpass students' conceptual understanding. In addition, the same findings also found in interview responses. The following opinions are representative of those presented in the interviews.

"Yes, I knew the meaning of the formula and how to use it. It means the only length affect the period of the simple pendulum. The mass and the angle of the pendulum does not affect the period of the simple pendulum."

The significant correlation between conceptual understanding and learning achievement (post-test) indicated that students who understand the simple pendulum concepts correctly also tended to have higher scores in learning achievement. Regarding positive correlation results, the interpreting graphs and conceptual understanding became two most important factors to affect learning achievement in experiment group. Pearson correlation in the control group also showed that interpreting graphs more correlated to hypothesis making (r =. 461, p =. 006), applying formulas (r =-. 618, p =. 000), conclusion-making (r =. 830, p =. 000), and learning achievement (r =. 358, p =. 038). The results demonstrated that interpreting graphs had an important role in physics learning as well as conceptual understanding. It is consistent with the results of studies (Lingefjärd & Farahani, 2017; Purba & Hwang, 2017a, 2017b) which showed interpreting graphs could help improve better conceptual understanding. The knowledge of interpreting graphs can be very helpful in physics experiment and become an important step towards expertise in problem-solving (Beichner, 1994; Larkin & Reif, 1979; Supalo et al., 2016; Zebehazy & Wilton, 2014). In addition,

Table 4. TAM questionnaire survey analysis

#	Item	ED (1)	MD (2)	SD (3)	NAD (4)	SA (5)	MA (6)	EA (7)	Mean	SD
	Perceived ease of U-Physics use									
1	I find it easy to get the U-Physics to do what I want to do.	-	-	6.1%	36.4%	9.1%	12.1%	33.3%	5.31	1.42
2	My interaction with the U-Physics is clear and understandable.	-	-	9.1%	24.2%	12.1%	18.2%	33.3%	5.44	1.41
3	I find the U-Physics to be easy to use.	-	-	9.1%	9.1%	21.2%	21.2%	36.4%	5.69	1.31
4	Interacting with the U-Physics does not require a lot of my mental effort.	-	-	12.1%	18.2%	18.2%	21.2%	27.3%	5.34	1.38
	Total								5.45	1.39
	Perceived usefulness of U-Physics app									
5	Using the U-Physics improves my performance in my physics class.	-	-	9.1%	15.2%	21.2%	27.3%	24.2%	5.44	1.27
6	Using the U-Physics enhances my effectiveness in my physics class.	-	-	12.1%	18.2%	9.1%	21.2%	36.4%	5.53	1.46
7	I find the U-Physics to be useful in my physics class.	-	-	12.1%	9.1%	30.3%	15.2%	30.3%	5.44	1.34
8	Using the U-Physics in my physics class improves my productivity	-	-	12.1%	21.2%	24.2%	21.2%	18.2%	5.13	1.29
	Total								5.38	1.35
	Perceived intention toward using U-Physics									
9	Assuming I have the U-Physics, I intend to use it.	3.0%	-	12.1%	33.3%	6.1%	15.2%	27.3%	5.00	1.62
10	Given that I have the U-Physics, I predict that I would use it.	3.0%	-	12.1%	21.2%	24.2 %	9.1%	27.3%	5.06	1.56
	Total								5.09	1.59
	Perceived learning attitude toward using U-Physics app									
11	All things considered, my using the U-Physics for my physics class is a good idea.	-	-	6.1%	15.2%	12.1 %	27.3%	36.4%	5.75	1.27
12	All things considered, my using the U-Physics in my physics class is a wise idea to learn the pendulums' concept.	-	6.1%	-	21.2%	3.0%	12.1 %	54.5%	5.84	1.56
13	I like the idea of using the U-Physics.	-	-	6.1%	9.1%	15.2%	18.2%	48.5%	5.97	1.26
14	Using the U-Physics would be pleasant.	-	-	-	15.2%	15.2%	18.2%	48.5%	6.03	1.13
	Total								5.90	1.32

ED-Entirely Disagree; MD- Mostly Disagree; SD- Somewhat Disagree; NAD- Neither Agree nor Disagree; SA- Somewhat Agree; MA- Mostly Agree; EA- Entirely Agree

studies (Golonka et al., 2014; Purba & Hwang, 2017a, 2017b) emphasized that interpreting graphs are one of the critical factors to affect students' learning. Furthermore, students' interview results showed that interpreting graphs are more important than others in learning physics because students spent more time for interpreting graphs. Students could not continue to the next steps if they did not finish interpreting graphs. The following opinions are representative of those presented in the interviews.

"I discussed and interacted with my peers during the interpreting graphs. I could not continue to others steps if my friend and I did not finish interpreting graphs."

"If I have different opinions of my peers during the interpreting graphs, I discussed again and asked teacher help."

Meanwhile, students' conceptual understanding increased when students interpreted their graphs correctly. So both interpreting and conceptual understanding are the key points to achieve a better learning achievement. Giving a daily life example (simple pendulum or swing) could also stimulate their motivation to learn physics. Therefore, physics teacher should tend to use graphs as a sort of the second language, assuming their students can extract most of their rich informational content and increase conceptual understanding.

The other finding is a significant negative correlation between hypothesis and conclusion making. It showed that students who make a hypothesis correctly tended to make the wrong conclusion. It may happen because students have less training after the experiment. Besides, it may also because female students have a lower self-confidence level than male ones in science learning (Mullis & Martin, 2008). Therefore, we suggest that teachers need to guide students how to conduct and make a better conclusion based on their findings. This phenomenon is interesting and worth further investigation in the future.

Students' Perception of U-Physics

The Table 4 shown the result of the questionnaire survey analysis. According to the results, most students' scores are high for the items of perceived learning attitude, perceived ease of U-Physics use, perceived of the usefulness of U-Physics app, and perceived intention toward using U-Physics.

The findings demonstrate that in general, students perceived that they are glad to use U-Physics and it was also easy for them to use. U-Physics was perceived useful for students during the experiment. We found that student learning attitude, ease of U-Physics use, and usefulness have high scores. Meanwhile, students' perception toward intention to U-Physics were the lowest. So we interviewed students to reveal the reasons behind the phenomenon. The interview result showed that an hour is not enough for them to repeat and do more practice during the experiment. Most students hope that they have more than an hour to learn physics and teacher will allow them to bring U-Physics back home. The following opinions are representative of those presented in the interviews.

"It is not enough. Maybe I need 2-3 hours in every week like science class usually."

"Yes, I will experiment if the teacher allowed me to bring U-Physics back home. Because I want to improve my study and I will show to my family or my brother so that we can learn together."

In terms of pedagogy, we recommend that interpreting graphs generated by U-Physics can facilitate students to find the critical variable of simple pendulums such as period and the length of the pendulum correctly and smoothly. The U-Physics also can help students to build their understanding of simple pendulum concepts. Besides, U-Physics is not just an excellent tool to measure the variable of simple pendulum accurately by providing graph rather than a traditional tool but also can link students' concept and experiment measurement in a laboratory. Therefore, we strongly suggest teachers and researchers should ask students to use graphs frequently in their physics phenomena solutions.

In terms of technical, we suggest that the acceleration sensor generated by U-Physics can collect the acceleration and velocity of the tablet during its swinging. The multi-representation such as graphs, text annotations, and many data integrated with U-Physics app can help teachers and teachers not only to build physics phenomena but also to organize and manipulate the sampling data for an in-depth analysis. Therefore, teachers and researchers should involve more representation skill in their teaching to help students learning as we did in U-Physics activities. In addition, teachers and researchers should design and utilize advanced features of mobile devices such as GPS, compass, acceleration, gyroscope, light, and gravity sensors for learning physics.

CONCLUSION AND FURTHER STUDY

The significant findings of both studies are outlined as follows. Firstly, significant positive correlations exist among hypothesis-making, interpreting graphs, applying formulas, conceptual understanding, and post-test. It indicated that the students' translation of verbal or vocal to mathematical pattern ability, transforming mathematical pattern into arithmetic symbol ability, and explanation of the solution by verbal writing ability can help student learning achievement. Particularly, interpreting graphs and conceptual understanding were the two most important factors to affect learning achievement. These two factors are key to continue others steps, so they need to spend more time to figure out the graphs and build their concept. Secondly, significant negative correlations exist between students' hypothesis-making and conclusion-making during activities. It indicated that a student who has low scores in hypothesis-making would get high scores in conclusion-making after the experiment, whereas a student who has high scores in hypothesis-making would get low scores in conclusion-making. It is because female students have a lower self-confidence level than male students ones in science learning (Mullis & Martin, 2008). Lastly, most students' scores are high for the items of perceived learning attitude, perceived ease of U-Physics use, perceived of the usefulness of U-Physics app, and perceived intention toward using U-Physics. In addition, students in this current study are glad to use the U-Physics, and it was also easy for them to use. U-Physics has also perceived usefulness during the experiment.

However, we found several limitations of this study. First, duration of experiment activities is insufficient, so students did not intend to use U-Physics. Second, participants in this study only evolved vocational female which cannot generalize all the user content very well. It might affect the result. Therefore, in future, we would like to expand the duration of experiment activities and allow students to bring tablet PC at home. Students can use U-Physics after class anytime and anywhere. The future study also needs to consider the gender of participants.

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The Didactic Contract to Interpret Some Statistical Evidence in Mathematics Standardized Assessment Tests

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ABSTRACT

In this study we analyse results of Italian standardized tests in mathematics integrating quantitative analysis based on the Rasch Model and didactical interpretation. We use specific graphs to analyse the trend of each answer as function of the students' math ability. This approach led us to focus on specific items in which a wrong answer results particularly popular among medium/high level students and analyse this particular trend with the lenses of math education theories. The study reveals that these phenomena are particularly related to implicit and explicit rules governing classroom practices exist at all school levels and regard different mathematical content and skills.

Keywords: didactic contract, mathematics education, mixed methods, Rasch analysis, standardized assessment

INTRODUCTION

In recent years, international standardized assessment such as OECD-PISA and TIMMS tests gained an increasing interest in particular concerning public opinion. At the same time, the results of this tests can be extremely productive in math education research field (Leder & Lubienski, 2015; Middleton, Cai & Hwang, 2015) but their usage is growing only in the last few years (Sfard, 2005).

Every year in Italy, the National Evaluation System entrust the administration of large scale tests to INVALSI[1]. The data collected and the analysis of results by INVALSI highlight macro-scale phenomena. Specifically, regarding the standardized mathematics tests, students' answers to some of the test items reveal behavioural attitudes that allow us to understand more in depth peculiarities of teaching and learning process and some causes of difficulty nationwide.

Recently, an increasing number of research studies have focused on students' math performances facing on national and international standardized assessment (Anderson, Lin, Treagust, Ross, & Yore, 2007; Arzarello, Garuti, & Ricci, 2015; Di Tommaso, Mendolia & Contini, 2016; Middleton et al., 2015); in details, some of these (i.e. Bolondi et al., 2016; Bolondi, Cascella, & Giberti, 2017; Mellone, Romano, Tortora, Statale, Mangino, & Pagani, 2013) show how often the didactic phenomena that emerged through statistical methods are not directly related to the mathematical content, but can be interpreted with mathematics education constructs, such as the didactic contract. In this research we went further that and we looked for statistical evidence that would allow us to have further information.

This research sets out to interpret and analyse some of the findings which emerge across the country in statistical analysis of the INVALSI tests, and which regard all school levels involved in the tests. For each test considered in this paper, the data analysed are those of INVALSI's sample which consists of approximately 30,000 students and

[1] From the official website of the INVALSI: INVALSI is a research institute with the status of legal entity governed by public law. The Institute carries out periodic and systematic checks on students' knowledge and skills, and on the overall quality of the educational offering of schools and vocational training institutes, also with a view to lifelong learning; in particular, it runs the National Evaluation System.

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Contribution of this paper to the literature

- The analysis of didactic phenomena emerged from standardized assessments fits in the international research in mathematics education and the introduction of innovative investigation methods, such as that shown in this research, are relevant for the research community.
- The innovative method of this research constitutes a development of existing research in mathematics teaching using data from standardized surveys as:
    - combines qualitative methods with quantitative methods extrapolating information on students' answers from statistical elaborations
    - consists in an item-level analysis that allow to understand deeper causes of specific students' answers and interpret them with the lenses of mathematics education theories
    - in particular, allows us to confirm and, therefore, study and develop the educational contract construct
    - the results obtained provide information for a well-defined category of students, identified on the bases of their mathematical ability level measured on the entire test.

it is representative of the population of Italian students attending that grade. The INVALSI statistical analyses are based on Classical Test Theory to provide the consistency of the test and on Item Response Theory (IRT) models, and in particular the Rasch Model to analyse items' features (INVALSI, 2017).

The Rasch Model (Barbaranelli & Natali, 2005; Rasch, 1960) is a one-parameter logistic model, it belongs to the *Item Response Theory* (IRT) category and produces a jointly estimate of the difficulty parameters of each test item and the ability parameter of each student.

Using this model it is possible to push the analysis of standardized assessment, often focused on the entire tests' results, to an item-level. As highlighted by Leder and Lubienski (2015), item level analysis of standardized assessment is particularly important because gives information concerning specific difficulties of students in mathematics and this allow researchers and teachers to intervene effectively.

In particular, item-level analysis provided by the Rasch Model allows us to express the probability of supplying the correct response to a test item on the basis of the difficulty of the question itself and the ability of the student as evaluated via the entire test. In general, higher student ability is matched by increased probability that he/she will produce the correct answer, whilst the number of wrong answers should decrease as student ability level rises. However, there are cases where this trend is not displayed – some items may offer a wrong answer which results particularly popular with medium/high level students.

Understanding the cause of this phenomenon is complex as various educational factors come into play, as has been frequently highlighted in the national and international literature of mathematics education. It concerns issues linked to implicit and explicit rules which govern mathematical practices in classrooms, particularly regarding the solving of mathematics tasks, which regulate the certainties and behaviour of students.

The study reveals that these phenomena exist at all school levels and regard different mathematical content and skills: a detailed key to such behaviour involves some well-known mathematics education constructs.

Moreover, this paper presents a research on the INVALSI mathematics test questions, beginning with the quantitative data collected by the National Evaluation System. The aim of the study is to propose an integrated analysis of the tasks which allows us to interpret some of the phenomena emerging in the quantitative results via qualitative analysis.

The introduction, both nationally and internationally, of standardized assessment tests such as OCSE-PISA, IEA-TIMSS, and INVALSI, can provide important data at a systemic level for mathematics education research (Looney, 2011). Although the main aim of this analysis is an assessment of the education system, and abilities and skills achieved by students at different scholastic levels, analysis of task wording and student performance may also offer important data for research purposes.

From this point of view, one "critical issue, which remains partially unresolved, regards the 'translation' of the quantitative statistic results of the national sample into information and proposals that may become effective driving forces of innovation rather than pure data which leave the door open to interpretations (often hasty and inadequately considered) that end up deeply distorting the objectives of the evaluation itself" (Bolondi et al., 2016). As explained before, to move in this direction, it is useful an item-level analysis that points out specific difficulties/strength of students and this can be supported by a qualitative analysis of the most interesting items throughout the lenses of math education theories. However, in some studies the test results have revealed some very interesting macro-scale phenomena (Branchetti et al., 2015; Bolondi et al., 2016; Bolondi, Cascella, & Giberti, 2017), such as new effects of the didactic contract; these findings may then be studied in depth via a mixed-method approach from QUAN to QUAL, performing first a quantitative analysis and later a qualitative analysis (Johnson & Onwuegbuzie, 2004).

The main aim of this study is to highlight the potentialities of an item-level analysis of standardize test data, combining both quantitative and qualitative analysis. Our hypothesis is that item-level analyses may provide a huge amount of information refer to teaching and learning processes.

THEORETICAL AND METHODOLOGICAL FRAMEWORK

Although Classic Test Theory (CTT) offers important statistical tools for the assessment of tests (Barbaranelli & Natali, 2005; INVALSI, 2017), the analytical studies presented in this paper and in reports of INVALSI test results are mainly based on the more modern Item Response Theory. This latter solution makes use of various mathematical models to measure latent variables and allows us to overcome the principal limitations of CTT, such as the dependence between estimated student ability and item difficulty.

In this context, we will consider the simplest IRT model which is also used in the main analytical studies of INVALSI tests: the Rasch model (INVALSI, 2017; Rasch, 1960).

The Rasch model is a one-parameter logistic model, and thus the simplest of the IRT models. It allows us to calculate the probability of correct response to a determined item, according to the ability of the student and the psychometric characteristics of the item itself (particularly, the item's difficulty).

The relationship between the student's ability and the probability of correct response to the item may be represented in a graph via a theoretical curve known as the Item Characteristic Curve (ICC).

Once the Rasch model is applied, we have the possibility to move our research to item-level analysis by observing features of specific graph output of the model. The examination of these graphs, called *distractor plots,* makes it possible to extract extremely useful information regarding each individual item. In the same graph as that where the ICC is tracked regarding correct answers (usually a continuous blue line – **Figure 1**), it is also possible to view empirical data regarding the correct answer and other alternative responses. In this way, it is possible to observe to what extent the empirical curve of correct answers be coherent with the theoretical curve, and also to analyse the trend of each distractor (i.e. incorrect response) according to the students' level of ability.

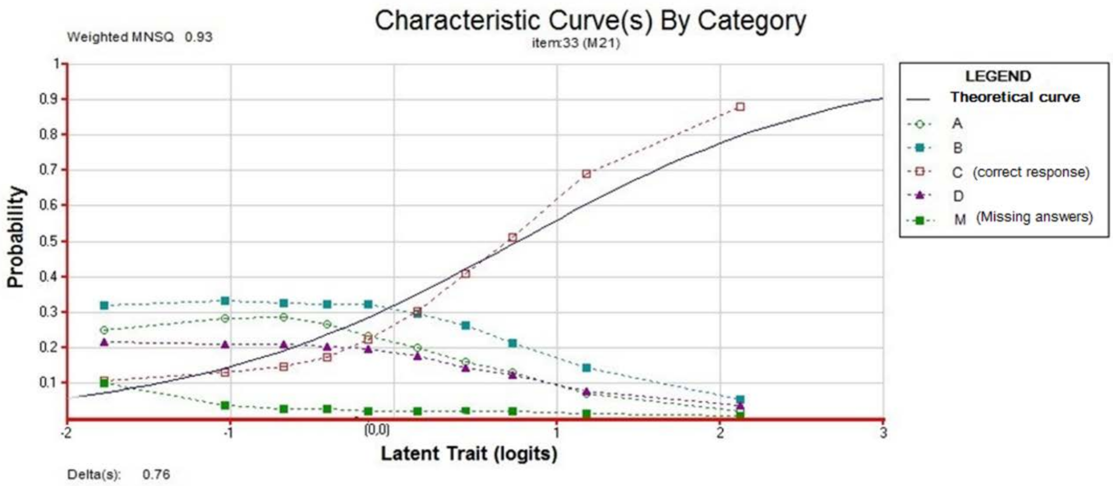


Figure 1. Example of a distractor plot for one item

The distractor plot on the x-axis (**Figure 1**) reports the Rasch score in terms of student ability across the entire test and, as already outlined, the continuous line represents the model's theoretical curve (ICC) which reveals the probability of correctly answering the questions according to student ability. The broken lines represent empirical data collected on each reply option for the item used. For the graph implementation, students are divided into deciles according to their level of ability as measured by the entire test, and, for each group of ten, the percentage of students who chose each answer is reported.

In this item, the comparison between the empirical correct answer trend and the theoretical curve results as acceptable (weighted = 0.93); it also appears, however, that in this case the model tends to overestimate the students with medium-low ability levels whilst underestimating high-level students. The most attractive option is B, which was chosen by a high percentage of students, including those of medium and medium-high level abilities. The other two options also display "good functioning" and were chosen by students of low and medium ability. Finally, it can be noted that only a few students did not answer the question, almost all of whom belonged to the decile with the lowest ability level.

The Rasch model can only be applied in cases where certain conditions exist, allowing the application of the model and estimate of parameters (Barbaranelli & Natali, 2005; Hambleton, Swaminathan & Rogers, 1991). In particular, unidimensionality, local independence and monotonicity of the test are required. The condition of monotonicity demands that (for each item) the probability of a correct response grows monotonically with the increase of the students' ability level and can be checked via the graphic representation of empirical data, i.e. by tracking the distractor plots.

From a strictly statistical point of view, it could be expected then that a higher level of student ability correlates with a higher percentage of correct answers for an item and, simultaneously, a lower percentage of wrong answers. Observing the responses to multiple choice questions (where there is only one correct answer but another two/three wrong answers are also suggested), it can be seen that the percentage of wrong answers given (considered as a whole and bearing in mind the missing answers) always decrease with the students' ability but, if the relative curves of the individual distractor items are considered separately, it is possible to see answers' trends which are not strictly decreasing (for example, the curve for option B in Item 24: 2, **Figure 2**).

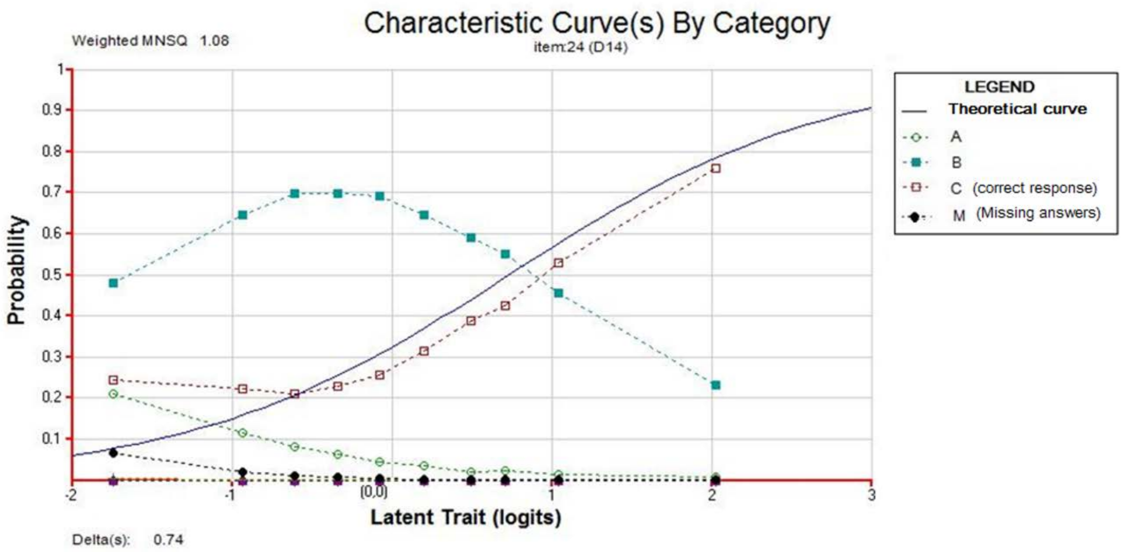


Figure 2. Example of a distractor plot for an item with decreasing performance in a curve regarding a wrong option

In the example shown in **Figure 2**, the curve related to option B reveals an increasing performance followed by a decrease which will henceforth be indicated as a "humped performance": the percentage of students choosing this option increases as student ability level rises in the low and medium-low deciles, whilst only from the fifth decile onwards does the curve show a decrease.

Analysis of this phenomenon (the "humped performance" of an option) is complex as various interactive factors come into play: students with varying levels of ability may encounter different obstacles when faced with a task, supply wrong answers for different reasons, and favour one wrong answer over another as a result of different approaches and problems.

Possible causes for the selection of wrong answers are often linked to factors regarding implicit and explicit rules established during teaching/learning processes which regulate mathematical task activity in class and often lead to wrong convictions. For an in-depth understanding of the reasons behind such circumstances, it is necessary to carry out a critical analysis of responses to the individual tasks via some mathematical education notions.

In this research, we focus on items from various school levels (from primary to high school) which display good measurement properties (Barbaranelli & Natali, 2005; INVALSI, 2017) and in which at least one option of response demonstrates a "humped performance" that may be linked to teaching factors. In particular, in the following examples, one of the main constructs that can supply a key to reading statistical results of this type at a systemic level is the *didactic contract*.

The didactic contract forms part of Guy Brousseau's Theory of Didactical Situations in Mathematics and refers to the set of the teacher's behaviours as expected by the student, and the set of student's behaviours as expected by the teacher (Brousseau, 1988; EMS-EC, 2012).

Specifically, in a teaching situation, prepared and carried out by a teacher, the student is generally given the task of resolving a (mathematical) problem, but the key to this task is found by interpreting the given questions, supplied responses, and the obligations imposed by the teacher's methodology. These (specific) habits of the teacher as expected by the student and the student behaviour expected by the teacher form the didactic contract

(Brousseau, 1980). This notion supplies keys to interpreting the various situations that emerge during classroom activity and has revealed itself to be a particularly useful tool in interpreting situations that arise during mathematical task-solving, also in standardized test conditions (Bolondi et al., 2016; Ferretti, 2015).

As will be revealed later, some facts which emerge can be analysed with notions already mentioned in the literature, such as the clause of the didactic contract entitled the "need for formal justification", and other ad hoc constructs such as the "Age of the Earth" effect of the didactic contract (Ferretti, 2015).

QUALITATIVE AND QUANTITATIVE ANALYSIS OF QUESTIONS: SOME EXAMPLES

The study presented in this article began by selecting INVALSI items which displayed a "humped performance" for at least one of the option items.

From an initial qualitative analysis of the individual item, it was revealed that in the majority of cases the response options included one linked to difficulty as highlighted in mathematical education research, and this precise option was linked to a "humped performance" by one of the distractors.

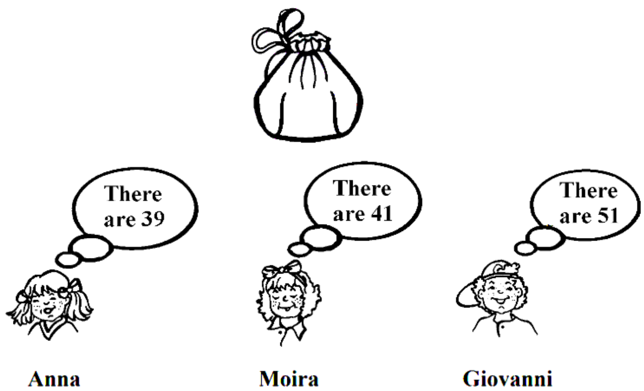
In the following section we present some examples of analysis of items referring to different mathematical fields and school levels.

The items selected are from INVALSI tests administered in different years (from 2011 to 2017) and at different school levels (from grade 2 to grade 10). The statistical analyses presented conform to those adopted by the INVALSI Institute during test validation and analysis of results, and are based on INVALSI samples comprising (for each test) 30,000 – 40,000 students nationwide. All the selected questions are multiple choice options and reveal good functionality in terms of model fit (weighted), discrimination, percentage of correct answers and point-biserial correlation between each answer and the overall ability of students (a negative correlation for wrong answers, and positive for correct answers).

In carrying out the study, we used the research tool GESTINV database (Gestinv 2.0., 2018; www.gestinv.it) which has already been verified in other research studies (Ferretti & Gambini, 2017) and from which we extracted all the results and graphs presented below.

The first example reported (**Figure 2**) refers to question D14 administered in the grade 2 mathematics INVALSI test of 2010/2011 (**Figure 3**), which belongs to the content area: "Numbers".

D14. Three children try to guess how many balls are in a sack (like the one below)



They open the sack and see that there are 47 balls.

Whose guess was nearest to the actual number of balls in the sack?

☐ A. Anna

☐ B. Moira

☐ C. Giovanni

Figure 3. Question D14 from the grade 2 test of 2011

From a quantitative point of view, it can be seen that this is quite a difficult item (delta=0.74) to which only 35% of students answered correctly. **Table 1** reveals that there is a very low percentage of missing answers (less than 2%), and most of the students who made a mistake chose option B (57% of the total answers).

Table 1. IRT and percentage of responses of item D14 from the grade 2 test of 2011

ITEM D14 – STATISTICAL FEATURES			
Cases for this item 31842 **Item Threshold(s): 0.73**	**Discrimination 0.29** **Weighted MNSQ 1.08**	**Item Delta(s): 0.74**	
Label	**Score**	**Count**	**% of tot**
A	0.00	2087	6.55
B	0.00	18216	57.21
C (correct)	**1.00**	**11104**	**34.87**
Missing	0.00	435	1.37

Furthermore, again from the data reported in **Table 1** and looking at the distractor plot (**Figure 2**), it can be noted that the item has a good functionality from a psychometric point of view: its fit with the model data is acceptable (weighted = 1.08) and it discriminates well between respondents with high and low levels of ability (discrimination = 0.29).

The item asks students to compare three natural numbers and identify the closest number to another one given. It is a question designed to gauge the students' ability in estimating and comparing natural numbers. The correct response is C; the other two response options are linked to two problem areas. Specifically, those students who chose option A may have concentrated only on the figure representing the tens of the number 47.

From this perspective, the students may have identified the number 39 as that closest to 40, revealing a difficulty in ordering natural numbers. The option A curve is decreasing and shows that the students who chose this option (around 6%) belong to the group of students displaying a low ability level in the test.

The option B curve on the other hand reveals a "humped performance" and is particularly attractive to students of medium level ability; furthermore, this option was chosen by a large percentage of students also among the higher level groups, and only in the last two deciles was the percentage of correct answers higher than that of distractor B. One possible reason for so many "good" students having chosen option B (41) as the answer could be linked to the fact that, in effect, this number is the only one proposed with a place value in tens the same as that of the number of balls in the sack (47). The students who chose this response may have been influenced by this similarity in tens, without considering the need to identify the "nearest" natural number.

In this case, then, it may be supposed that the students have a partial awareness of place-value notation of a number and thus stop only to consider the tens of the figure without comparing the entire number. The percentage of students who chose this option was 50% and an analysis of the distractor plot reveals that this did not only comprise students of low ability in test performance but also students with medium level scores. This fact reveals an interesting characteristic, i.e. that most students who showed difficulty in estimating and ordering natural numbers are mainly those who achieved average performance levels in the test.

One significant issue lies in the fact that in didactic practices usually the concept of estimation is tackled in the sense of "approaching something", implicitly meaning a "rounded-down estimate". The classroom task habits are revealed also in student performance during mathematical tasks, as a consequence of the didactic contract (Brousseau, 1988); the "humped performance" of the option which presents a rounded-down estimate may confirm the influence of the didactic contract in students' choices.

Another item of interest is question D5 from the grade 10 mathematics INVALSI test of 2011 (**Figure 4**).

D5. **The age of the Earth is estimated around 4.5×10^9 years. Homo Erectus appears about 10^6 years ago. What is the estimate that is closer to the age of the Earth had when Homo Erecus appeared?**

☐ A. 4.5×10^9 years

☐ B. 3.5×10^9 years

☐ C. 4.5×10^6 years

☐ D. 4.5×10^3 years

Figure 4. Question D5 from the grade 10 mathematics test of 2011

As we can see in **Table 2**, the correct answer (A) is chosen by only slightly more than 10% of students.

Table 2. IRT and percentage of responses of item D5 from the grade 10 maths test of 2011

ITEM D5 – STATISTICAL FEATURES			
Cases for this item 43458 **Item Threshold(s): 2.55**	**Discrimination 0.32** **Weighted MNSQ 0.97**	**Item Delta(s): 2.56**	
Label	**Score**	**Count**	**% of tot**
A (correct)	**1.00**	**4438**	**10.21**
B	0.00	2992	6.88
C	0.00	10084	23.20
D	0.00	24831	57.14
Missing	0.00	1113	2.56

The low number of correct responses highlights the difficulties students had in carrying out approximate estimation, numerical estimates, and ordering of numbers, as already revealed in the previous levels. One significant finding is that the correct response is one of the explicit data presented in the text and the failure to choose the correct response is part of a wider phenomenon already analysed in studies by Ferretti (2015) which reveal a new effect of the didactic contract – the "Age of the Earth" effect. Option B could have been chosen by students who mistakenly subtracted 10^9 from the age of the Earth without considering the difference in size ordering, whilst option C may have been chosen by students who made a mistake in the subtraction itself. In observing the Distractor Plot (**Figure 8**), it can be seen that such choices were mostly made by students who performed weakly in the test. In fact, the graph data reporting the choice of the two options decreases in line with higher student ability.

The most interesting option in this case is D, the most popular choice (selected by almost 60% of the sample group). This option may have been chosen by students who subtracted the exponent 6 present in the figure referring to the estimated time of arrival on Earth of Homo Sapiens from the exponent 9 in the estimated age of the Earth. From this point of view, the students may have mnemonically applied calculus tables linked to the property of powers.

The first interpretations of the phenomenon highlighted in the Age of the Earth question have linked student behaviour generically to the effects of the didactic contract as outlined by Brousseau (D'Amore, 2008). When given two numbers to the power of x, performing the subtraction of the exponents to carry out the subtraction of the numbers themselves represents a familiar operation to students as regards content but something which is completely wrong from a mathematical point of view. This behaviour can be tracked to a well-documented feature of the didactic contract, the need for formal justification (D'Amore, 2008).

As we can see from the Distractor Plot (**Figure 5**), the option D is the one favoured at all levels of ability, and the most popular choice of option for students of medium-high ability in the latent character scale; once again the curve relating to this option reveals a "humped" effect.

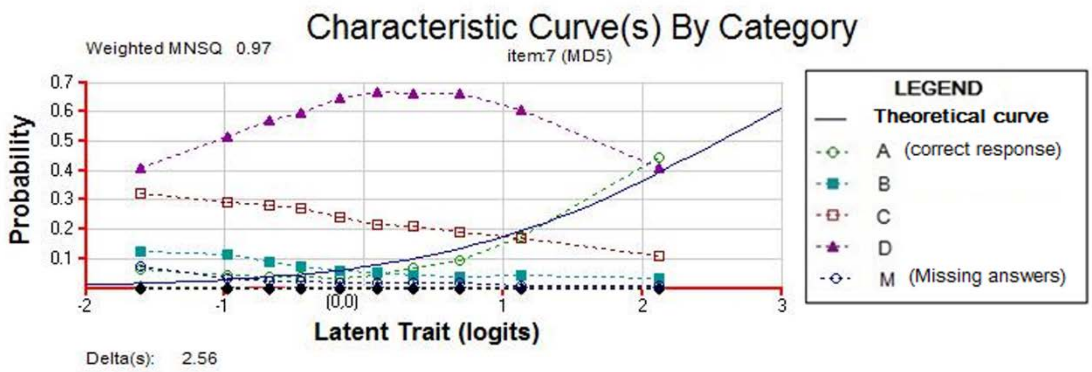


Figure 5. Distractor plot of item D5 from the level 10 mathematics test of 2011

The difficulties described above refer to the same mathematical field (Numbers) although at different scholastic levels. However, it is possible to identify questions with similar trends in other fields. The next example presents a task regarding the content "Relations and Functions" administered in the grade 5 mathematics INVALSI test of 2015 (**Figure 6**).

D7. Francesca prepares two meals a day for her cat, using tinned food.

With one tin of food, Francesca prepares 3 meals for the cat.

Francesca has bought 8 tins of cat food. How many days at most will they provide meals for?

A. ☐ 24

B. ☐ 16

C. ☐ 8

D. ☐ 12

Figure 6. Item D7 of the grade 5 mathematics test of 2017

This is a multiple choice item with the correct response being option D, which was chosen by fewer than 30% of students. To resolve this problem, the student must consider the entire text, understand the situation outlined, and focus not only on the numeric data give but also on the written textual content. As can be seen in **Table 3**, the question was quite difficult (delta = 1.10) and operates well in terms of fit with model (weighted = 1.04) and discrimination (discrimination = 0.35).

Table 3. IRT and percentage of responses of item 7 from grade 5 test of 2015

ITEM D7 – STATISTICAL FEATURES			
Cases for this item 22030	**Discrimination 0.30**	**Item-Total Cor. 0.35**	
Item Threshold(s): 1.10	**Weighted MNSQ 1.04**	**Item Delta(s): 1.10**	
Label	**Score**	**Count**	**% of tot**
A	0.00	10058	45.66
B	0.00	2407	10.93
C	0.00	2969	13.48
D (correct)	**1.00**	**6363**	**28.88**
Missing	0.00	255	1.16

Option B may have been chosen by students multiplying the number of tins by the number of meals per day. Option C could have been the choice of students who focused only on the number of tins without considering the information regarding the number of meals per day that Francesca prepares for her cat.

Regarding the Distractor Plot (**Figure 7**), it may be noted that these two options operate in a classic manner as distractors: both display decreasing monotonic function. The curve representing option A, on the other hand, shows a totally different behaviour from the other distractors and results as an option particularly attractive to respondents of medium ability. This option was chosen by a high percentage of students of every level of ability: in the lowest ability decile, it was chosen by almost 40% of students and only the two highest ability deciles favoured the correct response over this distractor.

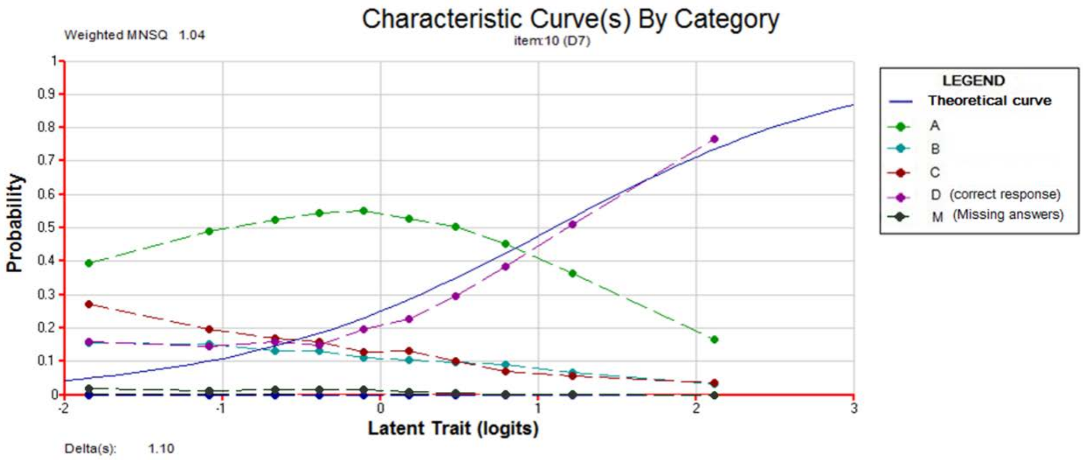
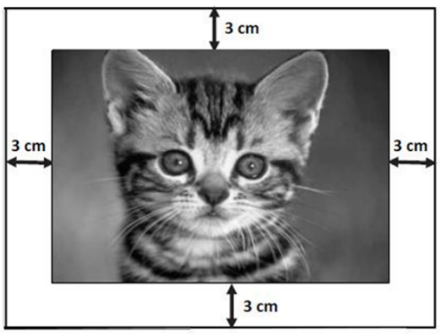


Figure 7. Distractor plot for item 7 from the grade 5 mathematics test of 2015

However, it can be seen that the choice of option A was highest amongst students of medium-level ability – more than 50% of students between the third and seventh decile groups chose this response option. This can be explained by referring to the “need for formal justification” hypothesis (D’Amore, 2008); it is possible that the students who chose this option did indeed identify all three data items present in the text but failed to grasp the problem situation posed and instead multiplied the figures in the text without checking the appropriateness of the calculation with regard to the situation presented. This type of behaviour is probably due to a teaching methodology based mainly on procedure; students who must resolve a problem tend to be asked to focus their attention on identifying data and the operation to be performed without reflecting more deeply on the situational problem posed. As you can see in the graph (**Figure 7**), students most affected by such a methodology are those of medium-level ability, who manage to identify the data presented in the question but in order to work out the solution turn to a procedure, to the identification of an operation that may however cause a loss of intended meaning and the wrong contextualization of the result.

Analogous behaviour can be noted in the content “Space and Shape” item; for example, in item D14 of the grade 6 mathematics test of 2013 (**Figure 8**).

D14. Franco glues a rectangular photograph sized 22cm by 15 cm on a sheet of card. A margin remains around the photo which is 3cm wide, as in the picture.



What is the size of the piece of card?

A. ☐ 28 cm x 21 cm

B. ☐ 25 cm x 21 cm

C. ☐ 28 cm x 18 cm

D. ☐ 25 cm x 18 cm

Figure 8. Item D14 from the grade 6 mathematics test of 2013

This case also comprises a multiple choice item with four response options, only one of which is correct (option A).

Table 4 breaks down the percentage of responses; only 26% of students replied correctly to the task. Option D, which was the most popular (chosen by around 50% of students) shows a "humped performance" in the distractor plot (Figure 9).

Table 4. IRT and percentage of responses of item D14 from the grade 6 test of 2013

ITEM D14 – STATISTICAL FEATURES			
Cases for this item 27416 Item Threshold(s): 1.17	Discrimination 0.29 Weighted MNSQ 1.06	Item Delta(s): 1.17	
Label	**Score**	**Count**	**% of tot**
A (correct)	**1.00**	**2747**	**26.43**
B	0.00	2514	9.17
C	0.00	2591	9.45
D	0.00	14235	51.92
Missing	0.00	829	3.02

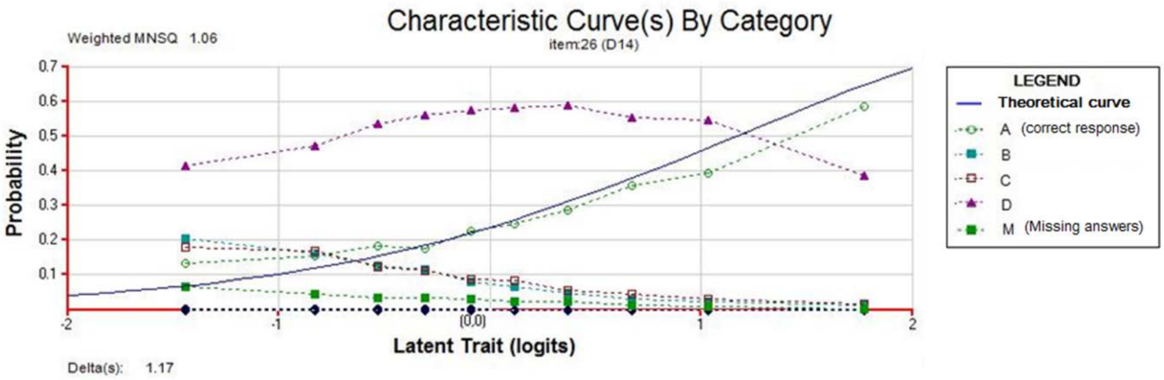


Figure 9. Distractor Plot for item D14 from the grade 6 mathematics test of 2013

One possible explanation for this choice echoes that of the previous item; in fact, it is feasible that students identified in the text the necessary data and operation for replying to the task and did so without checking the situation as modelled in the picture. In this case, the response option comprises the addition of 3cm to each of the photograph measurements.

CONCLUSIONS

In this paper we presented a research based on Italian standardized assessment, namely the INVALSI tests. Our aim is to highlight the potentialities of an item-level analysis of these data, combining both quantitative analysis based on the Rasch Model and qualitative interpretation of the findings through the lenses of math education theories.

Our hypothesis is that standardized testing data do not provide only rankings or scores related to benchmarks; they may provide a huge amount of information about mathematics learnings and feedbacks about teaching/learning processes. This information is contained not only in global scores (referring to the latent trait measured by the statistical models) but also in current phenomena, observed through the single items. According to Leder and Lubienski (2015, p. 35) "Item-level analyses can pinpoint the mathematics that students do and do not know, including which problems most students can and cannot solve, and which problems have the largest disparities between groups. This information can inform both textbook writers and teachers, as they strive to address curricular areas in need of additional attention. Hence, it is important for item-level analyses to be systematically conducted and reported".

In this paper we show that quantitative analysis of some items reveals particular item behaviour; the examples reported show that such behaviours are connected with well-known phenomena in mathematics education research, which are closely linked to classroom practices and the discipline's character. In this perspective, the examples provided highlight how statistical analysis are interesting for mathematics education. In fact, such statistical facts suggest that some well-known phenomena are measurable in terms of students ability in the test. In particular, focusing on *distractor plot* output of the Rasch Models, we identify some items in which the trend of one of the incorrect answers has a particular behaviour (it is more attractive for medium ability levels) and this behaviour can be explained using the didactic contract construct.

In order to confirm the research hypothesis, we carried out a statistical analysis on some INVALSI tasks by tackling different content areas (Numbers, Space and Shape, Relations and Functions) from different scholastic levels (from Primary School to High School).

From a statistical point of view, all the items analysed display good statistical features and are coherent with the Rasch model used for the test analysis (Barbaranelli & Natali, 2005; INVALSI, 2017). Analysing the distractor plots of all the items selected, however, it may be noted that in each there is at least one distractor curve that displays a "humped performance".

Looking for "humped performance" behaviour, we select several item in different mathematical content areas. In the example we present two item in "Numbers" (D14, D5), one in "Space and Shape" (D14) and one in "Relations and Functions" (D7). This fact suggest that such phenomena are not linked with content area but involves other factors linked with teaching and learning practices.

In the same way, we collect item from grade 2 to grade 10; this is totally contrary to the assumption that such factors are typical of low grade students, instead involving students of different school levels. For example, in D5 we show that 15 years-old students are particularly attracted to mnemonically applied calculus tables, just like grade 5 students who need formal justification.

The item were analysed through the lens of mathematics education, and the emerging results point to implicit and explicit rules established in the classroom, especially regarding the didactic contract (Brousseau, 1988) and we observed this particularly for specific students' ability levels.

The parallel between statistical analyses and didactic interpretation of the items allows us to verify the existence of the didactic contract and measure its effects; by analysing the distractor plots it is possible to identify which ability levels are most influenced by these phenomena. In particular, it can be seen that the effects result more evident regarding medium-ability level students. This is completely in line with the nature of the construct used to interpret the phenomena, a notion closely linked to classroom habits and repetition of tasks and resolution methods, in the presence of limited mastery of the content and concepts being used.

This initial study reveals that, regarding the items analysed, the effects of the didactic contract seem to affect particularly students of medium-level ability as opposed to other ability levels: the "humped performance" of the options displaying the phenomena under analysis may be due to the fact that students of low-level ability are not very keen on didactic practices, whilst better students manage to overcome the obstacles facing them thanks to their bond with the didactic method and their teacher. Furthermore, it is important to note that the phenomena encountered are often linked to mistaken knowledge or the result of bad teaching practices; this aspect then is not connected to absence of knowledge or non-participation in classroom activity, common markers of low-level performance in the tests. The close link that these constructs have with classroom practices would appear to confirm the statistical data: further analysis of other types of items covering a wider range of knowledge and mathematical skills could confirm these results.

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Chinese Students' ICT Readiness for a Blended Teaching and Learning Environment

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ABSTRACT

Information Communications Technology (ICT) plays an important role in enhancing Chinese students' learning efficiency and preparation for successful participation in a Western learning and teaching community. In the past, Chinese students' ICT preparedness for Western higher-education has not been emphasized in Chinese domestic K-12. Consequently, this lack of skills might be the cause tension between students and university academics in a blended learning and teaching environment. This pilot study used the Survey of Higher Education [15] to investigate 120 Chinese students between 16-18 years old who are commencing study in Australia and compared their responses with the expectations of 356 Australian academics. The results show that both Chinese students and Australian academics regard 'Data Retrieval and Data Management' skills as the most important skillsets. But gaps were discovered between commencing Chinese students and Australian academics in a number of communication and digital interactive skillsets used in a blended learning environment.

Keywords: blended learning, ICT proficiency, Chinese students, communication and interaction

INTRODUCTION

Information and Communications Technology (ICT) skills have been widely used for the last decade by students and teachers to enhance learning and teaching effectiveness. These ICT include using personal computers, Internet, mobile phones, digital music players, online games, etc (Adcock & Bolick, 2011). Due to the benefits ICT brings to education, learning models have changed from traditional 'teacher-centered' and text driven modes, to 'student-centered' modes driven by digital access (Primary teaching and learning tools also have changed from traditional print and written sources to multimodal tools delivered in a multimedia context. Since the introduction of the Internet (1983) knowledge of ICT skills to enhance online learning and teaching became essential for students' academic study.

Changes in academic policies are not easily made. Unfortunately, Western institutions are not known for flexibility and making rapid changes to their business models (AGBUC, 2013, p. 2). Administrators admit that *how to implement* a mutually beneficial technology programs lacks economic precedence and clear data. It is a "*work-in-progress*" and that often they are woefully unaware of their campus' grass-roots essentials (AGBUC - Association of Governing Boards of Universities and Colleges, 2013, p. 3). In such cases, they would better benefit by developing IT growth plans based directly on the expressed needs of the students and classroom educators, the two groups who are, too consistently, the last to be consulted in the decision-making process (Jones, 2013, p. 97).

Blended teaching and learning is a popular e-learning technology "capable of solving multiple tasks" and is often thought of as "a way that both educators and students can meet their teaching and learning needs" (Krasnova & Vanushin, 2016). This type of blended learning and teaching model is used all over the world, in both formal and informal learning, to improve the educational transformation and impact the learners' motivation (Nafukho, 2015).

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Contribution of this paper to the literature

- Providing decision-makers and stakeholders with the first-hand data to decision makers that they need to rethink and reorganize a flexible sustainable approach addressing the Academic ICT Gap
- Assisting Chinese international students to successfully transit to a blended learning environment.
- Improving understanding of the ICT gap between Chinese K-12 students and Australian academics.

An increasing number of Australian universities have adopted curriculum designs that blend teaching and learning models. Australia is an excellent resource for collecting Western higher education ICT data because of its unique features: geographical location, multicultural and multilingual population and political positioning in the Asian region. Though it is geographically located in Asia, Australia is similar to the other Main English-Speaking Destination Countries (MESDC) offering an English-language and quasi-national curriculum. Historical data indicates that the MESDC began integrating ICT into education in similar fashion and on similar timelines. All five countries offer similar theoretical and philosophical content based on their shared Greco-Roman, liberal arts tradition. Academically, the position of the Australian government with regards to higher education aligns with the current international trends that focus on authentic and sustainable assessment that have relevance beyond the classroom (Kearney, 2012, p. 876). However, the Australian government, in order to reduce institutional funding, supports an increase in blended learning, arguing that students and instructors would also benefit from the online delivery vehicle and the innovation it provides for research and data management (Crawford & Jenkins, 2017). Many Australian institutions express interest in adopting methodologies that provide more effective interaction and flexible choices between students and teachers. Such innovative methods merge two forms of teaching by combining face-to-face teaching techniques with simultaneous, online interactions.

Although blended learning and teaching has advantages, it requires both students and academics to have substantial ICT proficiency. In blended learning environments, students need ICT skills that are related to interactions with peers, collaboration with academics, and mentors, independent learning in data retrieval and data management (Krasnova & Vanushin, 2016). In the last two decades, the Ministry of China (MoE) has emphasized that schools and universities should improve technology infrastructure to enhance the effectiveness of using ICT tools in classrooms. However, disparities are still found between regional areas, larger cities and rural community schools in terms of ICT infrastructure, construction and teacher professional development programs (Lu, Tsai, & Wu, 2015). For this reason, Chinese graduates from K-12 might be expected not have the ICT skills required to succeed in the ubiquitous blended learning and teaching environment of Western universities. The discrepancy between Chinese students' training and the ICT skill-level expected by Western higher education in indicates a measurable Academic ICT Gap. This research study aims to provide decision-makers and stakeholders with the first-hand data they need to rethink and reorganize a flexible-sustainable approach addressing the Academic iCT Gap and assisting Chinese international students in the transition to the new blended learning environment in Western universities. The study significantly benefits Chinese international students and Western educators in their attempt to identify and better understand where the ICT gap lies and develop the curriculum to mediate the ICT gap before the Chinese K-12 students enter the Western universities.

BRIEF REVIEW

The Digital Age has had a major impact on fields, such as marketing, education, tourism, and health, making them more globally-competitive. China entered the Digital Age and quickly prioritized domestic economic development and the corresponding educational improvements required to support domestic growth. In 2000, the MoE instructed domestic schools thatChineseK-12 students should obtain ICT skills that strengthen students' information literacy, enhance students' learner autonomy and support life-long education. However, this directive was not compulsory and only provided administrative guidance. With no increase in funding and support for hardware, software, infrastructure and training, this priority ICT training was never initiated. Subsequently, long-standing disparities in access to technology education between rural and urban areas have resulted in unequal educations (Qian & Smyth, 2000; Zhang, Fang, & Ma, 2010). A recent large-scale study (Lu et al., 2015) revealed that Chinese K-12 schools in rural areas had profound differences in the application of ICT in classrooms, including materials design, construction of digital resources, and ICT learning environment. This is supported by Yu et al. (2016) who found that the effective use of ICT tools in Chinese K-12 education varied, as it was based on the teachers' work and subject load. The use of ICT tools supporting teacher effectiveness was more positive in English classes than in other subject area. In general, Chinese K-12 ICT education proficiency may be highly dependent on the school's locations, rankings and the quality of teachers' education. Yang, Huang, and Liu (2014) believe that if the Chinese central government allocated more educational funding into under-development areas the Academic ICT Gap could be narrowed.

Many Australian universities and colleges have adopted blended learning to support flexible learning and teaching environments. "The Turnbull Government's 2018 plan includes taking $2.8 billion in public funding from Australia's universities during the next four years" (IQPC cooperate, 2017, p. 1). This approach could severely impact the international student. This innovative model has attracted attention from K-12 educators, university academics, administrators and educational designers. The University of New South Wales, Western Sydney University, James Cook University and St. Stephens College have implemented blended learning programs across a range of faculties and disciplines to encourage students' active learning. Although these universities have made significant improvements in e-design, e-mentor, and learning management system (LMS), few studies have been conducted into the investigation of Chinese students' readiness in this blended learning environment. On the topic of ICT and the internationalization of higher education, universities often discount the input of its own researchers and instructors. "There is still too great a focus on political and economic rationales from an international and institutional perspective, in which the perspective of those for whom it is all intended are underrepresented" (Jones & de Wit, 2012)

Disregard for the ICT training needs of foreign students may be under reconsideration. Chinese students comprise the largest international student cohort in Australian schools. However, their ICT assimilation issues have not been addressed when compared with student health, stress and English language issues (Lu, Dear, Johnston, Wootton, & Titov, 2014; Price, 2016). Emphasis may change for economic reasons. Many academic studies have recommended conducting ICT skills assessment as a valuable student recruitment tool. However, this important tool has yet to be employed. Kennedy et al. (2008) and his colleges claimed that "little empirical research has been published on students' general use of technology in the context of Australian higher education (p. 109).

Han (2012) used a biographical approach to investigate Chinese HDR (higher degree by research) students' information literacy in Australia. She argued that "training in western countries has tended to regard international HDR students no differently from their undergraduate counterparts" (p. 3). Han's result showed that Chinese Ph.D. students faced significant challenges in technology information learning partly due to "their unfamiliarity with the terminology of library and information science in the new learning environment; and the previous academic culture and the political cultural value systems they experienced in their home country" (p. 15). Price (2016) found that the ICT skill expectations of 356 Australian academics was markedly different from the commencing international students. Multicultural factors have made it difficult to investigate domestic K-12 Chinese students' ICT proficiency to determine the influence it may have on their blended learning experience.

The studies above indicate that, although the Chinese government has paid attention to Chinese K-12 students' ICT education, their ICT performance and digital literacy are not sufficient to enter Western universities. In order to identify an Academic ICT Gap in the domestic Chinese population, it is essential that t obtain data from Chinese students who intend to enter Western universities and investigate if they are ready in being involved in blended learning environment.

THE STUDY

This study was the first stage of the big project that aims to develop personal Apps to enhance students' learning efficiency (iOS and Android) in blended learning. This blended learning model was designed for the Chinese K-12 graduates who would be enrolled in a joint programme with Western Universities, primarily located in Australia. These Chinese students receive the same quality of education as those entering domestic universities. The lectures will be conducted in the traditional theatre houses but tutorials will be delivered in various forms. Students could be provided with the recorded sessions if they missed the live-streaming lessons. In order to develop effective personal Apps, the researchers need have a better understanding of Chinese K-12 graduates' ICT proficiency. This study focused on examining the following two questions:

1) When conducting a self-assessment, what are the Chinese students' basic levels of ICT skills?
2) Do gaps exist between Australian university ICT requirements and the Chinese students' ICT proficiency?

This pilot survey was developed based on Price's study (2016)[1]. The question content was derived from curriculum standards and educational resources set by both Western and Chinese professional and governmental administrators (UNESCO, 2008). The first part of the project, as reported in this paper, used only quantitative research methods to complete data collection and analysis. Generally, the 'what' or 'how' questions could be answered more effectively by using quantitative research methods than qualitative research methods (Matthews & Ross, 2010). In this study, quantitative research methods are suitable as they are "concerned with collecting and analysing data that is structured and can be represented numerically" (Matthews & Ross, 2010, p. 465). It was conducted through a paper questionnaire for the sake of the participants' convenience.

The questionnaire survey was composed of three parts:

Table 1. Frequencies of Top-10 ICT skills most highly self-assessed by respondents

	Top-10 Proficient ICT skills	Yes%
Obtained	• Hardware - Smart phones	84%
	• Hardware - External storage, USB & thumb drives	80%
	• Interactivities - Mapping & location programs	77%
	• Data Retrieval & Research - Understand browser uses	77%
	• Spreadsheet Calculating - Understand terminology: column, row, cell	76%
	• Interactivities - Games & gaming	74%
	• Word Processing - Manipulate text	74%
	• Spreadsheet Calculating - Alignment & adjust column width & row height	73%
	• Hardware - Audio recorders or players	72%
	• Hardware - Video recorders or players	71%
	• L/CMS Skills - Access grades for units	71%

Table 2. Frequencies of students' least proficient ICT skills

	Least Proficient ICT skills	Yes%
Deficient	• Communication & Email - Reproduce academic formats	19%
	• Interactivities - 3D or animation software	12%
	• L/CMS Skills - Participate in a webinar	8%

- Part One: Background information in which students provided demographic information, such as gender, disciplines, and provinces.
- Part Two: 58 multiple choice questions asked students to rate their proficiency in various ICT skills common to academic use. They were given choices, Likert options of "Obtained", "Not obtained, but necessary" and "Important for study".
- Part Three A: open-response question asking students if they would like to receive ICT training and workshops
- Part Three B: open response question inviting students to make comments on the personal Apps (both IOS and Android) they currently use

The first part was composed of six question items mainly asked Chinese students' background and other demographic information. Students were asked to choose the most suitable answer. In the second part, the question items were grouped into six subgroups: Hardware; Multimedia Presentations; Interactive Applications; Research and Data Management; Spreadsheet Calculation and Word Processing. In this section, the students were allowed to choose multiple answers, if applicable. The final two questions of Part Three were designed to have a better understanding regarding students' perceptions of their personal Apps. These responses will be used for the Apps development and applications at the second stage of the project.

There were 120 volunteers from a research-intensive university ranked among the top-100 in China. Participants ranged in age from 16-18 years and represented 12 Chinese provinces. All had received their K-12 educations in Chinese domestic schools and had been accepted by Australian universities as self-funded or government-funded international students.

Responses were initially examined using frequency analysis to develop a ranking system, and then comparison analysis to determine how the student ranking compared with the academics' expectations as identified by Price (2016).

RESULTS

Although the 120 voluntary participants received the surveys, there were 119 participants signed the consent forms and completed the surveys. Anonymous paper surveys were issued and collected by the university's International Office. Eighty-percent (N=95) had science and technology backgrounds and 20% (N=24) studied various social science and humanities disciplines. Nearly half of the respondents expressed interest in ICT training and workshops to enhance their learning before and after university enrolment.

Frequency analysis was used to produce the students' self-assessed ranking of ICT-skill proficiency. After completing domestic K-12 educations, most Chinese students positively self-assessed their use of hardware, mastery of basic word processing, understanding of number calculations, basic data retrieval and research. **Table 1** provides a list of the Top-10 ICT skills self-assessed by respondents as their most proficient. **Table 2** lists 3 of the students' least proficient ICT skills. The students indicted that they expected it would be necessary to master these three skills once they arrive in their university environment.

Table 3. Expectations from Australian academics as expressed in Price's study [15]

	Question items	Yes%
Expected	• Hardware - Desktop & laptop computers	98%
	• Data Retrieval & Research - Use keywords in advanced search	95%
	• Data Retrieval & Research - Search sites with accurate information	94%
	• Data Retrieval & Research - Record, catalogue & cite data	93%
	• Word Processing - Manipulate text	92%
	• Hardware - External storage, USB & thumb drives	90%
	• Word Processing - Use reference, thesaurus & language tools	87%
	• Hardware - Printers, copiers & scanners	87%
	• Data Retrieval & Research - Understand browser uses	87%
	• Graphics Manipulation - Create clear, concise & logical presentations	86%

Table 4. The ICT gap between Chinese students and Western academics

ICT skill unit	Students (Yes) %	Academics (Yes) %	Discrepancy
• Interactives - 3D or animation software	65%	23%	-42%
• Interactives - Web development/editing tools	61%	31%	-30%
• Interactives - Media streaming	54%	43%	-12%

Chinese students indicated they understood basic L/CMS skills: how to access grades and unit work. Interestingly, they believe that they were more proficient in ICT related to their specific disciplines, such as mapping & location programs and games. However, two blended learning skills, communication with emails and webinar participation, need improvement.

Price's study (2016) presents the ICT use and student expectations of 356 university academics representing 12 of the total 31 Australian university systems. The academics were all experts in ICT technology, ICT instructors and technology educators in Australian public universities. Their views were collected after the research team obtained the Ethical approval of the research project by the University. These Australian academics were provided with a list of traditional ICT skills that were federally-mandated by the MESDC for inclusion into K-12 domestic education, over 20 years ago. **Table 3** indicates the Top-10 ICT skills required by Australian higher education.

When comparing academic responses in **Table 3** with student responses **Table 1**, there is commonality in the 3 ICT skills highlighted above in yellow.

Other notable finding:

1) Australian academics have high-expectations for a student's ability to locate and retrieve accurate data and then use that data in completing rigorous research projects.
2) Expectations include ICT skills related to identifying keywords when searching for information, identifying relevant sites and recording and citing data.
3) Only 30% of the student respondents self-assess as a competent in using references, language tools and graphics manipulation.
4) Less than 50% of the students feel proficient when using hardware like printers, copiers and scanners.
5) Although L/CMS-related skills were not ranked in the top 10 ICT skills required, more than 2/3 of the Australian academics surveyed believed that accessing learning materials and grades for units; discussing work on bulletin boards, and uploading assignments to the L/CMS were mandatory ICT skills that Chinese students should have acquired before entry to the Western universities.

Given the importance of skills in communication and interaction, gaps were found between academics and Chinese students' expectations. The details are in **Table 4**.

The data computation in **Table 4** indicates that many Chinese students believe that proficient use of interactive tools and software would be necessary in a blended learning environment: tools and software related to media, graphics and the Internet. However, the Australian academics indicated that these skills are not important in their L/CMS learning. Price believe that the discrepancies between student use and instructors' value of these Internet interactive skills are a possible indicator of the future of these emerging technologies as highlighted by the Academic ICT Gap study.

Students who develop *fast-fingering* skills using social media in everyday life are optimistic about their ICT proficient levels. *Fast-fingering* skills creates the illusion that users are adept and analysis of the responses for "Important for Study" indicates that at university. Chinese students intend to use social applications to successfully transition from formal K-12 instruction to informal, flexible blended learning and teaching environment. While manual dexterity may improve students' interface but it does not improve content management or research capabilities. Social media may prepare a student for the mechanics of L/CMS interface, but it cannot duplicate full immersion in L/CMS skills. When surveyed, many commencing students rank their ICT abilities as adequate and above. However, research shows that self-assessment of ICT skills is rarely accurate with most individuals, students and teachers, overestimating their ICT abilities (Jung, 2009).

In the open question section, the 59 Chinese students commented that they would like to be provided with free ICT training and workshops before and after they study in Australia. Regarding the last question, a considerable number of Chinese students held positive attitudes towards using online applications in blended learning. The popularity and favour of online applications were listed as: Easy access (N=102), Free usage (N=98), Peer interaction (N=83), and User friendly (N=70). Although Chinese students commented positively on the convenience and ease-of-download of personal Apps (iOS and Android, there was concern that using online applications out of classrooms would be time consuming and increase their Internet cost. Generally, most participants felt confident in choosing suitable online applications to assist them in blended learning.

DISCUSSION AND CONCLUSION

Two questions were posed, addressed and answered in the study. The MoE efforts to address Chinese students' ICT skills proficiency have not been overly successful. Unequal development in technology education still exists (Yang et al., 2014). Only 10 of 58 ICT skills were mastered by at least 70% of respondents. This result supported Han (2012), who posited that Chinese students could not be expected to have ICT proficiency comparable to their undergraduate counterparts in Australia. However, guidelines as to what ICT items a university-bound 2nd language learner must prepare for do not exist. A new expanded conceptual framework as to what kind of foreign language literacy students should acquire is needed. That framework would reflect the role of ICT in social, cultural, political and economic transformation, which in turn has a real impact on changes in the characteristics of foreign language literacy in the 21st century (Chauhan, Zhong, & Li, 2013, p. 411).

Chinese students lack ICT skills related to academic email etiquette, 3D software production and webinar participation. This result is in accordance with Zhang's study (2014) which indicated that Chinese students' ICT proficiency was heavily depended on their teachers. Chinese students would like to be taught in classrooms rather than exploring after school. Li and Ranieri (2010) surveyed over 300 middle-school students from Ningbo City, south of Shanghai regarding their ICT access and use. Of concern to the researchers was "the digital gap due to uneven opportunities for teenagers to access digital tools, and the emerging need to integrate the use of ICTs within the school system and into the curriculum (p. 1030). The lack of ICT education in daily coursework might also be due to the less funding on the infrastructure construction and teacher professional training in undeveloped areas (Yu et al., 2016).

This study provides insight into the attainment level of Chinese students' digital awareness since the ICT Innovative Programme was launched by the MoE (2000). Chinese students highly ranked the importance and their mastery of online interactivity and social communication skills. However, this is converse to the needs of Australian university instructors. The ICT skills most needed for higher education remain the same traditional ICT skills first introduced to educators in the 1990's. Even in Western K-12 education, these skills have been marginalized as they are not entertaining nor are they easy to self-teach. They must be presented to students in an authentic blended-learning context such as science investigation, mathematics computation, researching and writing projects. These skills are the key to successful blended learning L/CMS formats (Krasnova & Vanushin, 2016).

More importantly, this study supports the existence of an Academic ICT Gap between Chinese students and Australian higher education (Price, 2016). The major disparity is in the use of online interactivity and social communication tools: valued by the Chinese students surveyed but ranked at the bottom for university use. This result does not support the study undertaken by Adcock and Bolick (2011) who argued that skills related to online education were needed for both teachers and students in blended learning. Instead, recent research from Europe and America indicates that for sustained progress and educational transformation to occur, educational objectives and strategies do not require cutting-edge technologies. This is possibly an area in which emerging educational technologies can be identified. Definitive research is needed to develop subgroups of ICT skills in an educational context and that can be compared to broader areas such as fields-of-study and cultural teaching and learning conditions.

This study aims to determine if Chinese students are ICT ready to enrol in Western universities, particularly, in Australia. This is a pilot study with a small number of participants. In Stage II, we will make improvements on sample recruiting and use a mixed research method to gain further understanding of the Chinese students' digital literacy and their preference of personal Apps (iOS and Android).

Note 1 The Cronbach's alpha reliability coefficient (>p value) for the ICT items in questions ranged from .859 to .869 (58 items; α = .868). Therefore, the questions are considered to be highly reliable with a high level of internal consistency, since a figure of Cronbach's alpha >0.8 is taken to assure validity (Pallant, 2016).

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The Effect of Mobile-Assisted Language Learning Environment on EFL Students' Academic Achievement, Cognitive Load and Acceptance of Mobile Learning Tools

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ABSTRACT

This study reports on the investigation of the effect of mobile assisted learning environment on academic achievement, acceptance of mobile learning tools and cognitive load of EFL students. This study used a mixed methods approach which involves the collection and analysis of quantitative and qualitative data to identify the effect of mobile learning in a foreign language learning environment. Quantitative data were collected from 63 foreign language learners via an academic achievement test, cognitive load scale and mobile learning tools acceptance scale, before and after a six-week intervention period. Following the intervention, eight students from the experimental group answered open-ended questions about their experience during group interviews. Results showed a significant difference in academic achievement and mobile learning tools acceptance level of students in favor of the experimental group. The study also showed that although the students learning a foreign language in mobile assisted learning environment were not cognitively overloaded, students in the control group were. The themes emerged from the qualitative data point to the positive and negative sides of the mobile-assisted learning environment.

Keywords: academic achievement, acceptance of mobile learning devices, cognitive load, foreign language teaching, mobile learning

INTRODUCTION

The ubiquity of mobile devices has greatly changed the way individuals communicate, work and study in the 21st century. As smart phones and tablets become more easy-to-use and powerful, they will be an effective learning tool both inside and outside classrooms (Lin, Chen, & Liu, 2017; Sung, Chang, & Liu, 2016). Today, mobile devices are taking on a greater prominence in educational institutions (Hu & McGrath, 2011; Jin & Zhirui, 2017; Pegrum, Oakley, & Faulkner, 2013; Soruç & Tekin, 2017; Vazquez-Cano, 2014). The proliferation of mobile devices is constantly changing the way we interact and learn. Wang, Wiesemes, and Gibbons (2012) define mobile learning (m-learning) simply as learning anywhere, anytime through mobile devices.

The effective use of mobile devices necessarily requires understanding the scope of the contextual features of educational institutions with regard to implementation (Crompton Olszewski, & Bielefeldt, 2016). In the next fifteen years, mobile learning tools will undoubtedly become more integrated with mainstream education. Most students around the world will be able to bring and utilize their own smart devices since the necessary technology is expected to be more accessible, affordable and connected than it is today (Conejar & Kim, 2014; Crompton et al., 2016). The strength of mobile devices lies in the fact that they can be used for learning purposes. However, as is the case in much of the relevant literature, this paper also emphasizes that simply integrating mobile devices into learning process does not guarantee better learning. Integrating powerful mobile devices into instruction must also be accompanied by a pedagogical shift in order for students to benefit maximally from their use in the classroom.

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Contribution of this paper to the literature

- This study focuses primarily on how EFL university students' language skills are affected in a mobile-assisted learning environment.
- Both teacher-paced and student-paced applications were used in this study. A discussion of their potential advantages, disadvantages and the practical concerns related to classroom implementation is provided. This can help teachers better design mobile-assisted learning environments.
- This study also helps schools develop policies to control the use of mobile devices.

Like computer-assisted language learning, m-learning has also featured in the evolution foreign language learning has undergone over the past several years. Research has demonstrated that mobile learning technologies can be effectively used in vocabulary teaching (Chen & Li, 2010; Kim & Kim, 2012), to facilitate grammar teaching and help improve reading skills (Hsu, Hwang & Chang, 2013) and to enhance writing skills (Ivić & Jakopec, 2016). Other studies have shown that mobile learning tools can offer learners the chance to listen and record their own voice (Hwang, Huang, Shadiev, Wu, & Chen, 2014), which is associated with improvement of pronunciation and communication skills. Furthermore, mobile learning tools provide multimedia interaction opportunities and a collaborative environment whereby learners can develop and improve their speaking skills (Hwang et al., 2014; Hwang, Shih, Ma, Shadiev, & Chen, 2016; Liu & Chu, 2010). Multimedia content can be beneficial to students by enabling multimodal learning as long as the methods of delivery, storage and presentation are adjusted to the capabilities of mobile learning tools and the cognitive capacity of students (Milutinović, Labus, Stojilkovic, Bogdanovic, & Despotovic-Zrakic, 2015). Hence mobile applications for language learning ought to be designed to support mobile learning methodologies and to cover learning content.

Integration of mobile devices to support language practice and facilitate language learning have also extensively investigated. Some studies have found that mobile phones and tablets, when used appropriately, may assist students in improving academic achievement (Huang, Lin & Cheng, 2010; Ivić & Jakopec, 2016; Lu & Yang, 2018). In a meta-analysis, Sung, Chang, and Liu (2016) found that using mobile devices in education had a medium effect size for learning achievement. That is to say, most of the students using a mobile device performed significantly better on dependent variables related to achievement than the students not using mobile devices. Hwang et al. (2014) found that language students had positive perceptions and intentions toward learning activities using mobile learning tools; thus, students were motivated to practice foreign language skills more when using a mobile learning tool. An increase in motivation to learn using mobile devices is supported by a range of studies, including work by Ciampa (2013), Huang, Lin, and Cheng (2010), Rogers (2011), and Zheng, Chen, and Kong (2017). However, a mobile phone can be a potential distraction as Froese et al. (2012) indicated that students who freely texted during the lesson scored much lower than those who muted their phones during instruction.

Integrating mobile devices with multiple teaching/learning strategies is necessary for a better learning achievement (Sung, Chang & Yang, 2015). As Deegan (2015) claimed, mobile applications are rarely developed by teachers or pedagogues. However, it should be noted that teachers have the liberty to choose apps which best serve their purposes in classrooms. Thanks, in part, to the growing number of possible mobile applications available for language learning, the number of language teachers who can design mobile-assisted language learning environments has increased.

Theoretical Framework

The main theoretical framework of the current study is based on cognitive load theory, and its role in instructional design, along with the technology acceptance model.

Cognitive load theory is concerned with the conditions under which learners can best absorb and retain new information without overwhelming their limited short term memory resources. Cognitive load is typically increased when learners are dealing with complex problems for which they need to use their schemas (Paas, van Gog, & Sweller, 2010). If they haven't acquired the necessary schemas, or if the instructional procedures are poorly designed, such that the extraneous or intrinsic, rather than germane, types of cognitive load are involved, working memory will not be able to successfully retain all the bits of information contained in the task, thereby hindering effective learning (Paas & Ayres, 2014; Paas, Tuovinen, Tabbers, & Van Gerven, 2003). This theory may help explain how students, with similar language abilities, who are exposed to the same course content within different learning environments, handle information with varying degrees of difficulty. Especially during the last two decades, researchers have pointed out that the cognitive load of learners can be a good indicator of the efficacy of new teaching methods or learning technologies (Deegan, 2015; Paas, van Gog & Sweller, 2010; van Merrienboer & Sweller, 2005). As mobile learning may have unique characteristics that traditional acceptance theories have difficulty in addressing, a model specifically for technology acceptance was preferred in this study to explore EFL students' willingness to use mobile learning tools.

Statement of the Problem

Mobile devices have become learning tools with great potential for use both inside and outside of the traditional school setting. Although there have been qualitative analyses of the use of mobile devices in school settings, systematic quantitative analyses of the effects of mobile-assisted learning environments are lacking (Sung, Chang, & Liu, 2016; Vazquez-Cano, 2014). Milutinović et al. (2015) asserted that most of the studies in the m-learning field spotlighted a single aspect or a single activity of mobile-assisted language learning. In spite of the fact that mobile devices are increasingly used in school settings, there is a dearth of research on the overall effectiveness of mobile-assisted language learning (Sung, Chang, & Yang, 2015).

Within the framework of mobile devices as learning tools, m-learning may affect the extent to which learners can benefit from the environment and how they handle information overload within different learning environments. The purpose of this research is fourfold. The first goal is to determine the effect of the intervention on the students' academic achievement. Secondly, this study tries to determine the extent to which mobile learning tools are accepted by students. Thirdly, this paper examines the impact of mobile assisted language learning on students' cognitive load. Lastly, the paper tried to address what the students in the experimental group think about the process of mobile assisted language learning. Considering the related studies on EFL students' learning, both degree of acceptance of mobile learning tools and cognitive load might be strong predictors of academic achievement, Based on the literature review, the following research questions were asked in this study:

(1) What is the effect of mobile-assisted language learning environment on the students' academic achievement?

(2) How different is the mobile learning tools acceptance scores of students in the experimental and control groups?

(3) How different is the cognitive load of the students in the experimental and control groups?

(4) How do the students in the experimental group perceive the mobile-assisted learning environment?

METHODOLOGY

This study followed an intervention mixed methods approach (Creswell, 2015), in which both quantitative and qualitative data were collected to enable an in-depth study of the efficacy of the mobile-assisted language learning environment, which only students in the experimental group experienced. The present study used both quantitative and qualitative data to better describe and interpret the ways in which the teaching and learning processes take place in the mobile-assisted learning environment. Quantitative data were collected via questionnaires in order to address to explore the difference in students' academic achievement, mobile learning tools acceptance scale and cognitive load. Qualitative data were collected by means of a semi-structured focus group interview which allowed for an in-depth examination of participants' perspectives on the effectiveness of the learning environment and the identification of the sources of cognitive load.

Participants

Purposeful sampling was selected as the sampling method for this study. In the process of sampling selection, the criterion sampling was also applied to select the subjects. Participants in this study were 63 university students enrolled in two different classes in a year-long compulsory English language preparatory programme. This study was carried out throughout one semester with two compulsory foundation year classes within the preparatory English language study programme. All students were at the A2 level of English, according to the CEFR guidelines. **Table 1** shows the participants' profile.

Table 1. Participants' Profile

	Experimental (n = 32)		Control (n = 31)	
Variables	***F***	**%**	***F***	**%**
Gender				
Male	19	59.4	19	61.3
Female	13	40.6	12	38.7
Age				
18	8	25	10	32.3
19	11	34.4	12	38.7
20	9	28.1	6	19.4
21	2	6.3	3	9.7
22+	2	6.3	0	0
Field of Study				
Engineering	20	62.5	21	67.7
Business	10	31.3	8	25.8
Tourism	2	6.3	2	6.5

The experimental group consisted of 32 students (13 females) and the control group was composed of 31 students (12 females). Most students in both groups were 19 years old. Before the intervention, experimental and control groups' students' MLTAS and academic performance test scores were tested to ensure that the normality assumption is fulfilled for the two groups.

As for the participants of the group interviews, eight students were chosen from the experimental group using the extreme case sampling methods. Of all the interviewees, four were underachievers and the rest were high achievers in the academic performance test.

Data Collection and Analysis

In parallel to the research questions, the data of this study were obtained through four channels by both experimental and control groups. These instruments and the research questions they refer to are specified below.

Academic performance test

A test examining students' academic knowledge and performance was developed. This test is composed of two sections. The first section contains multiple choice questions to assess listening, reading and language use. Section two assesses oral production and writing skills based on detailed grading rubrics for each skill. To do so, a pilot test containing 158 items was generated and administered to 97 students. The results were analyzed to ensure validity and reliability of the instrument. Following necessary modifications, another pilot test was administered to 126 students. The results were analyzed again for item discrimination and item difficulty index. The reliability of the academic performance test was measured using the Kuder-Richardson Formula 20 (KR20). The KR20 reliability coefficient for academic performance test was found to be 0.947.

The first section of the academic performance test comprised three subtests – listening reading and language use. This section had a total of 60 items; 20 items for listening, 20 items for reading, and 20 items for use of language (vocabulary and grammar).

The second section comprised a writing and speaking task, which were evaluated using two rubrics: one based on writing performance and the other based on oral production. The assessment of writing and speaking, by its nature, is not limited to one correct answer. Considering the main criteria of analytic rubrics, two initial rubrics were designed to categorize students' performance in writing and speaking. Upon revision of the first versions of the rubrics, based on a pilot study and the opinion of experts, the rubrics took their final forms. The rubric for oral production skills consisted of five categories: pronunciation, vocabulary, sentence structure, fluency and comprehension. The writing rubric also comprised five categories, namely, clarity, vocabulary, language control, punctuation and organization.

In this study, students' academic performance score was found by adding the score from the first and second sections. Each of the 5 elements assessed – language use, listening, speaking, reading and writing – accounted for one-fifth of participants' academic performance score.

Mobile learning tools acceptance scale

The Mobile Learning Tools Acceptance Scale (the MLTAS), developed by Ozer and Kılıç (2017) was used to assess the extent to which students accept mobile learning tools. The MLTAS consists of 19 items scored on a five-point Likert scale. The development of this instrument began with a review of studies using technology acceptance scales.

This review revealed that 33 items are commonly used to measure technology acceptance. These 33 items were modified for the current study to make them suitable for mobile learning tools. From an original pool of 33 items, the scale was reduced to 25 items after the exploratory factor analysis and was reduced from 25 to 19 items after the confirmatory factor analysis. This scale shows good reliability with a Cronbach's Alpha of 0.83. The MLTAS serves as a means of predicting learners' level of acceptance of mobile learning tools. Of the 19 items, five each measured "contribution to foreign language learning," "negative perception" and "voluntariness of use", while four items covered "perceived ease of use."

Cognitive load scale

The relationship between learners' performance in a mobile-assisted language learning environment and cognitive load scores were assessed by means of an adaptation of a cognitive load scale. A nine-point symmetrical category scale, developed by Paas and Merrienboer (1993), was used in this study. In this measure, participants provide a self-report of their mental effort by marking a numerical value, ranging from 1 (very, very low) to 9 (very, very high). Kılıç and Karadeniz (2004) have adapted the Subjective Rating Scale by Paas and Merrienboer (1993) to Turkish. For the reliability of the adapted version, the Cronbach's Alpha coefficient was found to be 0.78. Throughout the six-week study period, participants were required to indicate their level of mental effort immediately after every mobile-assisted learning activity. Each student's cognitive load score was calculated by averaging all the cognitive load scores obtained after each learning activity.

Focus group interviews

In semi-structured focus group interviews, 8 students from the experimental group were asked to answer several questions related to their experience in the mobile-assisted language learning environment. All the interviewees were asked for their permission to audio-record the interview. In order to determine expert validity, the items in the interview were sent to two experts to be examined for clarity. In the light of the feedback provided, the interview questions were revised and finalized. The questions were mostly centered on identifying strengths and weaknesses while learning in a mobile-assisted environment Due to ethical considerations, the interviewees' identities were anonymized. In order to select interviewees, the study used extreme-case sampling based on results from the academic performance test. The interviews were held in two sessions with four students in each. Analysis of this data involved four steps. In the first step, the two digitally recorded interviews were transcribed verbatim. In the second step, an initial coding of interview transcripts was done. In the third step, the emergent themes were identified. Finally, the themes were reviewed and revised to prevent overlap. Miles and Huberman's (1994) statistical technique for measuring inter-rater reliability was used. Based on 86 agreements and 17 disagreements between the coders while identifying the themes, a reliability of 0.83 was calculated. Disagreements in regard to identifying categories were discussed and resolved before both the researchers proceeded with coding the rest of the qualitative data.

Procedure

This study was carried out throughout one semester with two compulsory foundation year classes within the preparatory English language study programme. A one-week pilot study was completed in the fall semester of 2015 at a state university to observe and forestall any possible interference. After several improvements based on the evaluation of the pilot study, the start of the intervention was scheduled for the second week of the spring semester of 2016. Before the intervention, students in both the experimental and control groups completed the academic performance test and the MLTAS.

After the pre-tests were collected, the 32-hour intervention began. During the six-week intervention, the cognitive load scale was administered immediately after each activity. The experimental group learned in a mobile-assisted language learning environment whereas the control group learned without any mobile learning technology. **Figure 1** presents the experimental process.

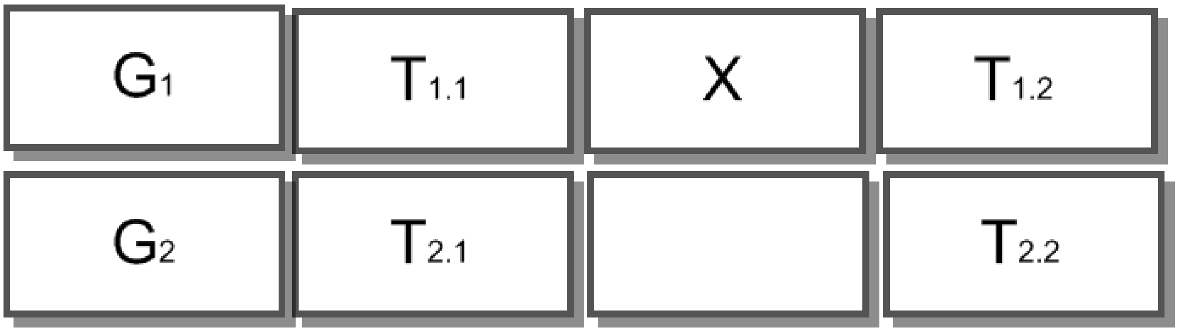

Figure 1. Experimental Process of the Study

Figure 2. Intervention Process in the Experimental Group

G_1 stands for the experimental group whose learning environment included course books, smart board, online and offline learning materials along with extensive use of mobile phones. G_2 refers to the control group whose classes were conducted under the same conditions as G_1, except that the online/offline learning materials and mobile phones were not present in the learning environment. $T_{1.1}$ and $T_{2.1}$ represent the pre-tests and $T_{1.2}$ and $T_{2.2}$ indicate the post-tests completed by the experimental and control groups, respectively. X represents the experimental intervention where students learned the content in a mobile-assisted foreign language learning environment.

The intervention was a mobile-assisted learning environment in order to facilitate students' listening, speaking, reading and writing skills along with vocabulary and language structures. The experimental group had an intervention that used course books, smart boards and mobile devices. The learning activities that were designed in the study were supported by a variety of mobile applications. The mobile applications included Johnny Grammar's Word Challange, Practice English Grammar and GrammarUp (to practice language structures), KelimeEzber, Tureng, and Wordweb (for vocabulary), Cambridge Advanced Dictionary and Longman Dictionary of Contemporary English (Online Dictionaries), BBC - 6 Minute English and Learn English with BBC (podcasts), Speaking Pal, Speech-to-text-translator TTS, Tureng and Longman Dictionary of Contemporary English (pronunciation), todaysmeet.com (backchannel for online conversation), SocrativeStudent, Quizizz and Kahoot! (classroom response systems for formative assessment), Youtube (video-sharing website), VoScreen (a tool for developing understanding of different languages), GoogleTranslate (multilingual machine translation service).

During the six-week intervention, 31 students representing the control group were in a learning environment which included the same materials and equipment that were used for the experimental group except for the mobile devices. As the application of mobile learning tools was the key variable of the study, the control group students used printed dictionaries, course books and smart boards.

After the intervention, the academic performance test and the MLTAS were administered. After that, semi-structured interviews were conducted with the experimental group students so as to more deeply understand the processes students went through in the learning environment. The intervention process is shown in **Figure 3**.

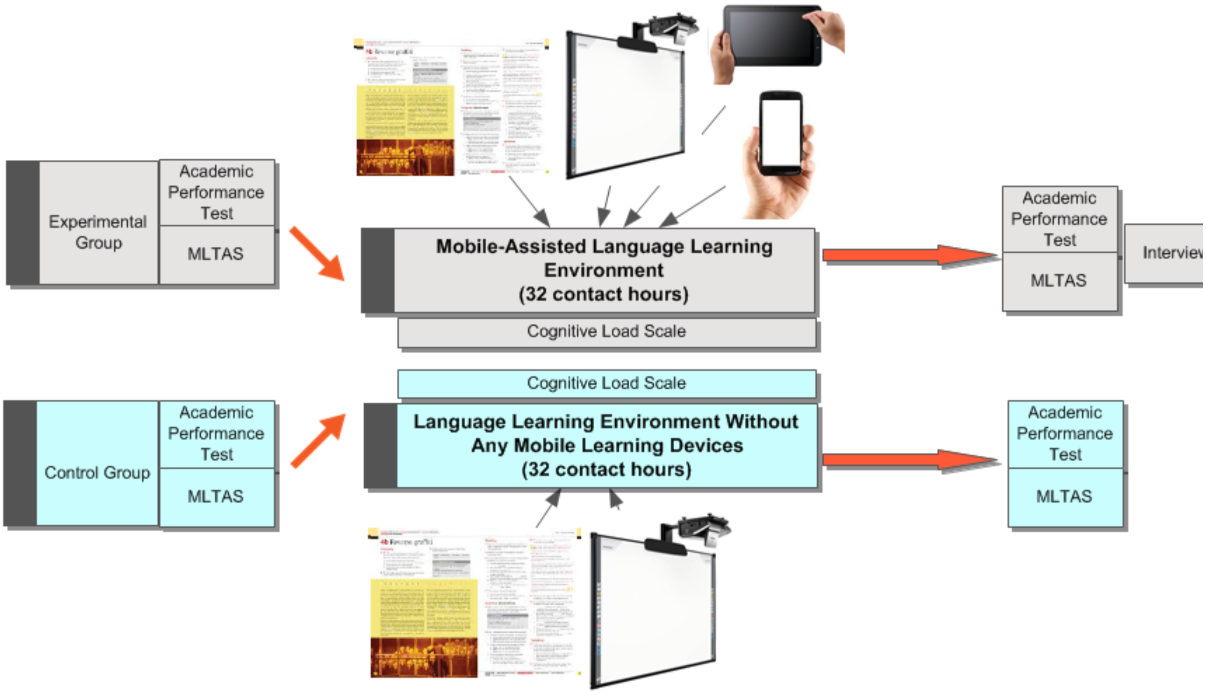

Figure 3. Intervention Process

Table 2. The t-test results for the academic achievement gain scores

Group	N	Pre-test $\bar{X}$	Post-test $\bar{X}$	Gain Score $\bar{X}$	SD	t	p
Experimental	32	50.23	67.09	16.86	6.04	5.75*	.000
Control	31	49.59	58.36	8.77	5.06		

*p<.01

Table 3. The t-test results for the MLTAS gain scores

Group	N	Pre-test $\bar{X}$	Post-text $\bar{X}$	Gain Score $\bar{X}$	SD	t	p
Experimental	32	73.97	78.34	4.38	9.47	2.81*	.007
Control	31	74.74	72.52	-2.23	9.15		

*p<.01

RESULTS

Analysis of Quantitative Data

In order to answer the first research question which investigates the effect of mobile-assisted language learning environment on the students' academic achievement, academic performance test gain scores were analyzed and the results are presented in **Table 2**.

As indicated from **Table 2**, it was found that the students in a mobile-assisted environment outperformed the control group students in regard to academic achievement gain scores. Results of an analysis of variance and t-test also showed that gender and field of study had no significant effect on the students' academic achievement gain scores. Also a large effect size was calculated for the magnitude in difference in means (Cohen's d = 1,065).

The second research question aimed to investigate whether there is a significant difference in the level of MLTAS between experimental and control group students. The results of the t-test for both groups are shown in **Table 3**.

The results of the analysis demonstrated that those in the experimental and control groups showed different levels of acceptance of mobile learning tools following the intervention. At post-test, those in the experimental group showed an increase in MLTAS scores, which differed significantly from the post-test MLTAS scores of those in the control group. Results of an analysis of variance and t-test showed that gender and field of study had no significant effect on the students' MLTAS gain scores.

Table 4. Results of cognitive load scale assessment and t-test

Group	N	$\bar{X}$	SD	t	p
Experimental	32	4.08	1.16	-4.191*	.000
Control	31	5.60	1.68		

*p<.01

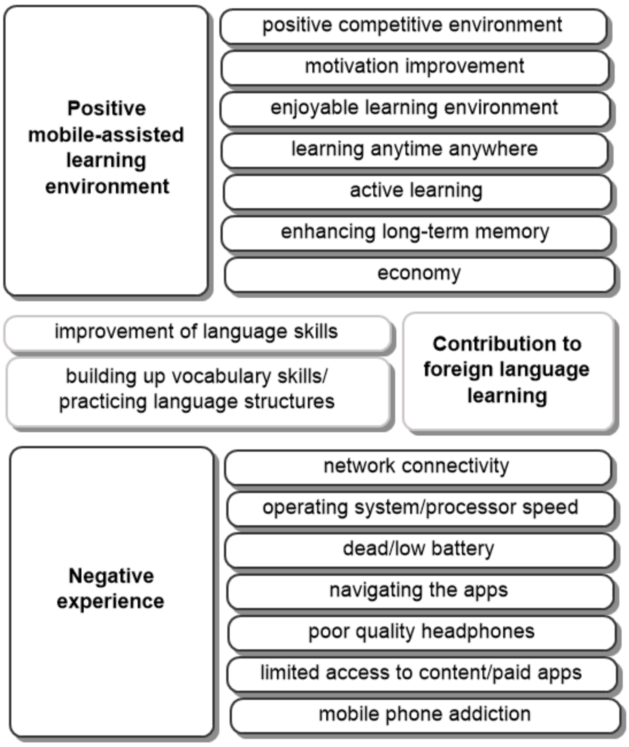

Figure 4. Themes and sub-categories with respect to students' m-learning experience

In an attempt to answer the second research question, the perceived mental effort of the two groups of students were measured after each activity during the intervention process and the collected data were analyzed using an independent samples t-test. **Table 4** provides means and standard deviations from the analysis with respect to the cognitive load scale.

As seen in **Table 4**, students in the experimental group had lower cognitive load compared to those in the control group. Results of an independent samples t-test confirmed that this difference was statistically significant. With regard to the mean amount of mental effort invested, only three students in the experimental group self-reported high mean mental effort to solve the problems while 19 students in the control group did so. Results of a one-way ANOVA and t-test showed that gender and field of study had no significant effect on the students' cognitive load.

Analysis of Qualitative Data

Figure 4 presents the themes and sub-themes that emerged from interviewees' responses to questions related to their mobile-assisted foreign language learning experience.

As seen in **Figure 4**, the themes that emerged were "positive mobile-assisted learning environment," "contribution to foreign language learning" and "negative experience." These themes are interrelated and no particular theme is of higher value. Participants identified a number of their experiences and coping strategies. A quote for each theme is included below to support the interpretation. The first theme focused on the positive aspects of a mobile-assisted language learning environment. Many students, like the following participant, reported experiencing distinct advantages when learning via mobile phones:

I think it is enjoyable because there was, as I said, a competitive [learning] environment. And the [the list of] top five rankings pops up, people compete [then]. I don't get bored. (EG-5F).

The second theme deals with the contribution to foreign language skills. More specifically, this theme explored how mobile-learning activities affected the foreign language learning process. One participant said:

> *Our writing [skills have] improved. As our vocabulary and grammar expanded, our writing [skills] has also improved naturally. We started to use more words, different words, not the same ones repeatedly. We started to use different grammars [a variety of language structures]. Not only [did we use] the active sentences but also the sentences in passive and with relative clauses. We did not improve only in writing [rather] we started to use them in speaking too. (EG-3-F).*

The negative experiences students had in the mobile assisted learning environment comprised the third theme. It encapsulates seven sub-themes from network connectivity to mobile phone addiction. One of the participants expressed his experience in the following quote:

> *Apps which we can use outside the school help us more when they run offline. Because umm we cannot always access internet, so we have times when we don't have any [network] connection. We cannot use online apps then. That's why an offline app is more useful for us. [I mean] in those situations. [However,] in the classroom online apps are more helpful. (EG-7M)*

DISCUSSION AND CONCLUSIONS

This study looked into how students are affected when learning in a mobile-assisted environment in terms of academic achievement, acceptance of mobile learning tools and cognitive load. Additionally, group interviews were conducted in order to probe and uncover the underlying beliefs of students towards mobile-assisted foreign language learning.

Unlike most previous research on mobile learning, the present research took a holistic perspective on language learning in order to identify the effects of mobile learning tools on academic achievement - that is, the emphasis was on all four language skills. The results of quantitative data analysis for academic achievement showed that only students in the experimental group experienced a statistically significant gain in academic achievement, a finding which was further supported by a large effect. Importantly, these results were not affected by the participants' field of study. It was also concluded that learning performance in a mobile-assisted environment did not vary by gender. This result is consistent with the results of Chung and Chang (2017). It is clear from these findings that the mobile-assisted learning environment has a significant positive effect on students' academic achievement. This conclusion is supported by a number of past research, including work by Bahrani (2011), Chen and Li (2010), Hsu, Hwang, and Chang (2013), Hwang, Huang, Shadiev, Ivić and Jakopec (2016), Hwang et al. (2014), Kim and Kim (2012), Lu and Yang (2018), Stockwell (2010), Sung, Chang, and Liu (2016), and Sung, Chang, and Yang (2015).

A significant increase was observed in acceptance rate of the students in the experimental group, indicating that these students accepted mobile learning technologies significantly more than those in the control group following the intervention period. Students in the control group actually showed a slight decrease in their acceptance of mobile learning technologies. This may be due to the fact that students did not use their mobile devices in class for a period of six weeks. The increase in the MLTAS gain scores of students in the experimental group, however, may be due to the pleasure and usefulness they perceived in the mobile-assisted learning environment. A possible positive relation might be assumed between the increase in academic achievement and the acceptance rate of mobile learning tools. Liaw, Hatala, and Huang (2010) indicated that factors such as encouragement of learners' autonomy and system functions that enrich interaction are predictive of acceptance of mobile learning technologies. When students enjoy using the mobile learning tools for retrieving online content and for gathering online resources they tend to keep using them. The more motivated the students are towards learning through mobile phones, the more likely for them to gain better academic achievements.

To broadly understand the students' cognitive load, students' scores on the cognitive load scale were examined. It was found that students in the experimental group generally perceived a low level of mental effort when completing learning activities, whereas cognitive overload was reported by students in the control group. Integrating self-paced and teacher-based mobile activities turned language learning into a more engaging and interactive process. When students engaged in activities, the teacher monitored students' learning and encouraged autonomous learning. This result corresponds with results of past studies which reported a decline in cognitive load of students in a mobile-assisted learning environment (Homer, Plass, & Blake, 2008; Klatzky, Wu, Shelton, & Stetten, 2008; Shadiev, Hwang, Huang, & Liu, 2015). This finding also contradicts results of prior studies which did not find a significant decrease in students' cognitive load (Chu, 2014; Wong, Leahy, Marcus, & Sweller, 2012). One of the reasons why students who learned in the mobile-assisted language learning environment obtained favorable learning achievements with no cognitive overload may be activation of prior knowledge via mobile learning tools. Huang (2018), Kalyuga, Ayres, Chandler, and Sweller (2003), and Wong et al. (2012) indicated that students with low levels of prior knowledge may experience cognitive overload because of the large amount of simultaneous mental processing that is required under these conditions. Collaborative activities done in this study focused heavily on newly created knowledge, thereby allowing students to reflect on areas where they had difficulties. Teacher-based collaborative activities may be especially effective at reducing the mental efforts students devoted since students shared experience and knowledge in order to complete these tasks. As in action learning sets, these kinds of activities can involve inquiry-oriented practice towards obtaining meaningful data, and may help reduce cognitive load, thereby allowing students to make effective learning decisions. Additionally, Salvetti and Bertagni (2016) concluded that activation of prior knowledge and learning by doing based on knowledge visualization via mobile learning tools can leave students with a profound and memorable experience. This knowledge visualization can help students reduce the mental effort involved in complex tasks, especially.

The interview data yielded key information regarding the beliefs about the mobile language learning environment. The themes which emerged from this data included "positive mobile-assisted learning environment," "contribution to foreign language learning" and "negative experience." In a positive mobile-assisted learning environment, students can learn at their own pace and enjoy learning. Numerous studies support the finding that with regular and effective use of mobile learning tools, students are more likely to enjoy learning (Bahrani, 2011; Başoğlu & Akdemir, 2010; Fernandez-Lopez, Rodriguez-Fortiz, Rodriguez-Almendros, & Martinez-Segura, 2013; Gingerich & Lineweaver, 2014; Motiwalla, 2007; Rogers, 2011) and better perform in the subject (Fleischer, 2012; Hwang & Chang, 2015; Sung, Chang, & Liu, 2016; Sung, Chang, & Yang, 2015). Contribution to foreign language learning was another theme that emerged from the interview data. Based on the results of the interviews, reading, writing and listening were the most affected skills, respectively by the mobile learning environments. In similar studies, researchers found that mobile learning can help students improve their vocabulary and language structures (Bahrani, 2011; Chen & Chung, 2008; Huang, Yang, Chiang, & Su, 2016; Stockwell, 2010; Sung, Chang, & Yang, 2015), as well as their proficiency in the four major language skills (Bahrani, 2011; Chang & Hsu, 2011; Demouy & Kukulska-Hulme, 2010; Kim, 2013; Wang & Smith, 2013). As for negative experiences, the main issues reported by students were problems with battery life, internet connection, operating system/processor speed, earphones/microphones, mobile application navigation and smartphone addiction. This result corresponds with studies showing that mobile learning activities can be affected negatively by technical problems involving battery life (Milutinovic et al., 2015; Rogers, 2011), internet connection problems (Farley et al., 2015; Godwin-Jones, 2011; Hanafi & Samsudin, 2012), operating system/processor speed (Farley et al., 2015; Rogers, 2011), earphone/microphone-based problems (Ally, 2013), mobile app navigation (Conejar & Kim, 2014; Milutinovic et al., 2015; Rogers, 2011) and smartphone addiction (Griffiths, 2013; Hadlington, 2015; Hawi & Samaha, 2016; Ophir, Nass & Wagner, 2009; Samaha & Hawi, 2016). Recent studies exploring the effects of classroom mobile phone use on students' academic achievement report that mobile phones can be distracting and information processing can be impeded if students text or post to social media in the classroom (Calderwood, Ackerman & Conklin, 2014; Kuznekoff & Titsworth, 2013; Rogers, 2011; Unesco, 2012). For this reason, teachers are expected to check the students' devices carefully before the activities and fix or replace a device when necessary in accordance with the requirements of the activity. To sum up, mobile learning technologies have clear benefits for language learning. A profound understanding of the nature of motivation and acceptance of technology in a mobile-assisted language learning environment can be used to enhance academic achievement. It is reasoned that the mobile-assisted learning environment has a positive effect on students' acceptance, cognitive load and academic performance. When students enjoy using mobile learning tools, they tend to keep using them; and, the more students use these tools, the more likely they are to experience academic gains. As long as the language learning environment offers equal access to every student regardless of ability and flexible learning opportunities, students are expected to perform better academically. Consequently, germane cognitive load increases since students are more motivated to participate in activities and as it is easier for the teacher to provide feedback via mobile learning tools. The findings of this study are helpful to those teachers who intend to design a mobile-assisted language learning environment and to those researchers who have been working on the effects of mobile learning tools on foreign language learning. In the meantime, since this study focuses primarily on how EFL university students' language skills are affected in a mobile-assisted learning environment, it is worth investigating the effects of similar learning environments on other subjects with younger age groups.

LIMITATIONS

Some limitations of the current work are worth mentioning. First, the study depended on the validity of the data collected from 63 EFL students during the spring semester in 2015-2016 academic year. The relatively small sample size may have underpowered some of the analysis. Another limitation was the fact that, only Android and IOS based freeware applications were used in this study. Future research will be needed to replicate these results using other operating systems and applications. Finally, this study is limited by the speed of internet connection provided by the institution. Unstable or slow network connection might have delayed task completion and motivation.

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Creativity of Pre-service Teachers in Problem Posing

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ABSTRACT

Problem posing and technology are attracting the attention of mathematics educators because of their potential to affect positively many aspects of students' learning. Little research has been done on the relationship between technology and mathematical creativity. The present study investigates this issue in the context of problem posing, in the presence and absence of a strategy for problem posing (the "what-if-not" strategy). Participants were pre-service mathematics teachers. The research was conducted during the academic year 2013-2014. Participants were randomly divided into four groups of 19 to 21 participants and who differed in their use of technology and of the what-if-not strategy. The participants who used technology used the Paper Pools applet. The data was collected from the participants' posing problems on a specific mathematics situation; the Paper Pool situation. The data analysis was done using SPSS 18.0. The research findings indicate that the combination of technology and the what-if-not strategy has a positive and significant effect on the three components of participants' creativity: fluency, flexibility and originality. Separately, both technology and the what-if-not strategy had a positive and significant effect on participants' fluency and flexibility related to problem types, but not related to strategy types. The findings also indicate that the originality of participants who worked without technology but with the what-if-not strategy was significantly lower than that of participants who worked with technology, whether with or without the what-if-not strategy. Thus, results indicated that technology is more effective than the what-if-not strategy in encouraging originality in problem posing. We recommend the use of technology together with the what-if-not strategy to enhance pre-service teachers' mathematical thinking, because this combination makes available for student's learning multiple agencies required for his/her creative acts.

Keywords: creativity, problem posing, pre-service teachers, technology, what-if-not strategy

INTRODUCTION

The main focus of the present paper is on problem posing as a creative experience of pre-service teachers and how this creative experience is affected by the use of tools, such as what-if-not strategy and technology. Researchers (e.g., Bonotto, 2013) point at problem posing as a form of structured "rich contexts" creative activity (Freudenthal, 1991) in which students can be engaged with the support of artifacts and human interactions (English, 2009).This description of problem posing makes it necessary to examine the influence of tools, namely technology and what-if-not strategy on students' creativity in problem posing tasks. The current research intends to do so, when pre-service teachers pose mathematical problems related to the Paper Pool task and which will be described in the methodology section.

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Contribution of this paper to the literature

- It investigates the creativity of pre-service teachers in in problem posing in four environments that differ from each other in the use of technology and what-if-not strategy.
- It uses mainly a quantitative methodology but it combines with it a qualitative methodology to find the categories of the participants' flexibility in problem types and problem strategies, as well as of the participants' originality.

Problem Posing

Problem posing and solving are two main components of teaching and learning mathematics (Akay & Boz, 2009; Leung, 2013; NCTM, 2000). Problem posing helps advance the development of mathematical ability and autonomy of learning (Kilpatrick, 1987; Mamona-Downs & Downs, 2005). Mathematics educators are interested in problem posing because of its capability to affect positively the problem-solving abilities of students, as well as other features of student learning, such as high order thinking including creative and critical thinking. Problem-posing tasks require the composition of new problems by changing the given conditions of the original one. The composition of new mathematical problems are expected to help investigate a given or a new situation (Silver, 1994).

Stoyanova (1998) categorised problem-posing experiences as: free, semi-structured, and structured. Free problem posing experiences involve unrestricted posing of problems; semi-structured problem posing experiences involve students' engagement with writing problems that are similar to the given or based on a specific feature. Structured problem posing experiences involve posing problems by restating an already solved problem or by modifying the conditions of a given problem. In the current study, structured problem-posing situations were used. These situations were related to the Paper Pool task. Utilizing the mathematical situation, the participants posed problems using one or both of the following tools: technology and what-if-not strategy.

The what-if-not strategy was introduced by Brown and Walter (1969, 1990) as a tool to extend the problem situation. It is based on generating new and interested problems through modifying the givens of an original problem. Teachers who implement the what-if-not strategy can move away from rigid teaching that consists of only one right way to a problem. Through this strategy, students can discuss different ideas and consider the different meanings of the problem (Brown & Walter, 1993). Carrying out this strategy, students begin with the examination of the problem. Doing that, they produce a list of the features of the problem. This producing of the list of features is followed, for each feature, by asking the what-if-not question and proposing alternatives to the original problem. Afterwards, the students utilize the alternatives to formulate new problems.

Studies that investigated problem posing using the what-if-not strategy reported on the type of problems posed by participants, on the effect of its use on the problem-posing activity of students, and on the students' difficulties in problem posing. For example, English (1998) analysed processes that eight-year-old students performed when they were asked to pose problems using the what-if-not strategy in formal or non-formal contexts. English found that the children offered different problems by changing the conditions of non-formal problems, but had difficulty varying the conditions of formal ones. Lavy and Bershadsky (2003) reported on pre-service teachers use of the what-if-not strategy to generate problems based on a complicated space geometry task. The results indicated that pre-service teachers posed a wide range of problems, including some in which they replaced a numeric value with another, and including problems that engaged proof. The problems they posed shed light on some phenomena, but lacked formal generalization. Kilic (2013) investigated the problems that pre-service primary teachers posed on fractions. Kilic found that the participants produced primarily story problems, with some non-story problems or/and irrelevant ones.

Technology in problem posing

Technology has the potential to make problem-posing richer, because it can efficiently take care of the computing and graphing and all other technical work (e.g., Lavy & Shriki, 2010). Specifically, the interface of the tool facilitates the procedures used by the users, so it impacts positively their understanding (Christou, 2005). Furthermore, the dragging functionality of the software grants students the potentiality of reasoning visually and generalizing problems (Sinclair, 2004). In other situations, technology helps students verify the validity of the new situation (Lavy & Shriki, 2010).

Abramovich and Cho (2015) investigated the use of graphing software, as a tool for reciprocal problem posing. They found that this tool was effective for posing advanced problems about algebraic equations that include parameters. Moreover, Beal and Cohen (2012) found that middle school students were able to generate mathematics and science problems using a web-based sharing system with content-authoring capabilities. These results make it possible that technology contributes positively to students' problem posing.

Of special interest, concerning problem posing, is its positive effect on students' creativity (Silver, 1997; Silver & Cai, 2005; Singer, Ellerton, & Cai, 2013). Creativity as an aspect of mathematics learning has been a rising topic of mathematics education research in the past two decades. In the present study, we examine the impact of technology and a problem-posing strategy on mathematical creativity of pre-service teachers.

Creativity in Mathematics Education

In mathematics education, only lately researchers have shown interest in creativity research (Leikin & Pitta-Pantazi, 2013; Sriraman, Haavold & Lee, 2013). This interest has risen due to different factors as the call of mathematics education researchers (e.g., Haylock, 1987). Another factor is the functions of creativity in the 21st century by itself and because it is interconnected with other 21st century skills (Pásztor, Molnár, & Csapó, 2015). specifically, problem solving and posing often requires creative ideas. This is especially true for mathematical problem posing, where emergence of new and intriguing problems is enriched in a creative environment.

In spite of the attempt of various researchers to define mathematical creativity, no proposed definition has been universally accepted (Mann, 2006). The definitions of creativity given by the different researchers can be put into two categories: those concerned with the final product and those concerned with the process (James, Lederman-Gerard, & Vagt-Traore, 2004). Sternberg and Lubart (1999), who adopt the point of view of the final product, describe it as the ability to produce an unexpected work. Researchers who define creativity as a process describe it as the capability to think in a conceptual way. The current article is based on a definition of creativity as a process, which involves three components: fluency, flexibility, and originality (Guilford, 1950, 1975; Torrance, 1966). Our adoption of fluency, flexibility and originality for studying the creativity of pre-service teachers in a problem posing context is also supported by Silver (1997) who claimed the three components are established within the studying of creativity. These claims are stressed again by Sriraman, Haavold, and Lee (2013) who argue that varying combinations of the three components have been used to study mathematical creativity.

In the current research, fluency is related to the number of correct questions that a student produces for a problem. Flexibility is related to the number of question types proposed for a problem. Flexibility is also related to the number of problem-posing strategies that a student has implemented. Originality is related to the number of problems posed that no other person or very few proposed (Leikin, Koichu, & Berman, 2009; Torrance, 1969, 1974).

Studies on mathematics creativity report its positive effect on student learning (Lai, 2011; Mann, 2006), suggesting that creativity tasks are highly effective in the mathematics classroom. At the same time, Sriraman (2005) argues that nurturing creativity is not a strategy usually implemented by teachers. It is therefore necessary to introduce pre-service teachers to creativity during their study as mathematics teachers. This is especially true when this introduction is accompanied by tools, such as what-if-not strategy and technology, which could enhance the creative work of these pre-service teachers.

Technology in creativity

Researchers (Hoyles, 2001; Liekin, 2011; Yerushalmy, 2009) point out that technological tools can enhance the mathematical creativity of students and sustain the attempts of teachers to escalate the mathematical inquiry of students. Specifically, Yerushalmy (2009) argues that technology supports students' cognitive processes, as questioning, conjecturing and exploration, which stimulate their mathematical creativity.

Two disagreeing views populate the literature about the relationship between creativity and technology (Clements, 1995). The first claims technology develops merely mechanistic and uncreative thinking, while the second claims that technology develops creativity. The latter view is consistent with the claim of the National Advisory Committee on Creative and Cultural Education (NACCCE, 1999) about the role of technology. This argument claims that technology assists students in finding new ways of creativity. This argument is consistent with the results of empirical studies that have pointed at technological environments as enhancing students' creative capabilities (e.g., Dunham & Dick, 1994; Subhi, 1999).

Examining mathematical creativity in technological contexts, some studies have taken a close look at the interactive whiteboard environment (Behzadi & Manuchehri, 2013; Sophocleous & Pitta-Pantazi, 2011; Wood & Ashfield, 2008). The results of these studies emphasize the positive effect of technology on students' mathematical activity, reporting that the technological tool offers students opportunities to imagine, synthesize, and elaborate, in other words, to be creative. By contrast, Wood and Ashfield (2008) pointed at the teacher's skill and professional knowledge as mediating the interaction between students and technology and as facilitating the growth of students' creative answers in the presence of technology. Both arguments support the call to introduce creativity, especially with technology, into the curriculum of pre-service teachers. The present research relies on work carried out on creativity in problem-posing tasks with and without technology.

Creativity in Problem Posing

Voica and Singer (2013) argue that there is no agreement among researchers of mathematics education regarding the relationship between creativity and problem posing, where some of them claim that this link is rather strong, while others claim that problem posing has the potentiality to enrich creativity. For example, Haylock (1987) considers problem posing as a creative ability. On the other side, Silver (1994) commented that a general relationship between problem posing and creativity remains to be demonstrated. Furthermore, cognitive flexibility in the modification of a problem indicates mathematical creativity (Voica & Singer, 2013).

We describe in detail two studies related to the present one, as they reported students' and teachers' problem posing for the same task: "the Paper Pool". In the first study, by Silver, Mamona-Downs, Leung, and Kenny (1996), the researchers investigated problem posing among middle school teachers and secondary school pre-service teachers. Participants were asked to pose mathematical problems either individually or in pairs—before, during, or after the solution of a problem that was part of the paper pool task. The authors examined the types of problems posed and the cognitive processes used in the problem posing, as well as the differences between problems posed in the course of the phases of student work: before solving the task and during or after solving it. Results showed that the participants posed a large number of reasonable problems during the phases. Participants posed problems in two ways: keeping the conditions of a problem and manipulating these conditions. Participants' experience in solving the problem affected their problem posing. Finally, participants posed also problems that they could not solve.

Kontorovich, Koichu, Leikin, and Berman (2011), who also examined students' work with the paper pool activity, investigated the problem posing by high-achieving secondary school students, and described their fluency, flexibility, originality, and aptness. The authors differentiated between three problem-posing strategies: (a) accepting the givens as they are; (b) varying the givens (table dimensions, starting point of the ball, the initial angle of the ball, and the number of balls); and (c) introducing new types of givens.

The present study investigates pre-service teachers' creativity in problem posing in the Paper Pool context in four environments differing in the use of technology and what-if-not strategy.

Research Rationale and Goals

Lavy and Bershadsky (2003) argue that developing mathematical problem-posing skills is especially important for the teachers of mathematics because integrating problem-posing activities in the mathematics class facilitates the assessment of their students' mathematical knowledge. According to this approach, it is required that problem-posing tasks be part of the preparation of pre-service mathematics teachers. At the same time, researchers indicated that addressing creativity conceptions in pre-service teachers' preparation would encourage them to foster creativity in their students (Bolden, Harries, & Newton, 2010). Regarding the activity of problem posing by pre-service teachers and by students, researchers paid attention to the use of the what-if-not strategy. Silver (1997) has claimed that problem-posing tasks encourage student creativity, and that using a what-if-not strategy encourages student flexibility.

Technology, on its part, can also support creativity (Buteau, 2008) and even stimulate mathematical creativity for all levels of students (Yerushalmy, 2009). Previous research has studied mainly the contribution of technology alone or what-if-not strategy alone to creativity tasks. The present study examines the contribution of each one of them and their combination in creativity in the problem posing setting.

Research Questions

1. Does the use of different tools (technology and what-if-not strategy) result in significant differences in pre-services teachers' creativity in mathematical problem posing, in each research group, before and after the use of these tools?
2. Does the use of different tools (technology and what-if-not strategy) in problem posing result in significant differences in creativity among the research groups according to the use of different combinations of the tools?

Table 1. Cross-tabulation of use of technology and of the what-if-not strategy

		Technology		Total
		Without technology	With technology	
What-if-not strategy	Without what-if-not	21	19	40
	With what-if-not	20	19	39
Total		41	38	79

METHOD

Research Settings, Participants and Design

Participants were pre-service mathematics teachers. The research was carried out during the academic year 2013-2014. Participants were randomly divided into four groups that differed in their use of tools (what-if-not strategy and technology). Two of the groups, after being introduced to the what-if-not strategy, were requested to work with the Paper Pool task using it. One of the previous two groups was introduced to technology too; specifically to a Java applet, so that the members of this group worked on the task using the combination of the tools - what-if-not strategy and technology. The third research group was introduced to technology alone, as previously mentioned a Java applet, so this group members posed problems on the Paper Pool task using this applet. The fourth research group worked without using any of the tools. **Table 1** shows the frequency of participants in each of the research groups. All the research participants had not used the java applet or what-if-not strategy before the experiment.

The participants who were introduced to a tool, whether what-if-not strategy or technology, did that in two lectures, each of two hours, where in the first lecture they were introduced to the techniques and options of the tool, while in the second lecture they posed problems with the tool, where the problems were not on the Paper Pool situation.

The participants in each one of the four groups performed the activity twice, once before the experiment, where all of them posed problems without technology and without what-if-not strategy. The participants performed the activity again after two weeks in which part of them were introduced to the tools. Furthermore, the participants in all groups had one hour to perform the task. They worked individually, in contrast with Kontorovich et al. (2011). Participants in the two research groups, who utilized technology, worked with the Paper Pool Applet[1]. The same teacher, who was the second author of the paper, worked with the four groups and tried not to interfere with the pre-service teachers' work, for example not to give feedback on the correctness of the problems posed by a student in any of the groups.

Statistical computations using ANOVA indicated that the mean score of the participants in the four groups before the experiment did not differ significantly regarding the four components of creativity. These results were $F(3,75)=.55$, $p=.65$ for fluency; $F(3,75)=.12$, $p=.95$ for flexibility of problem types; $F(3,75)=.16$, $p=.92$ for flexibility of strategies; and $F(3,75)=.03$, $p=.99$ for originality.

Task

The task in the current research was used in a study by Silver et al. (1996), and it was used also by others as Kontorovich et al. (2011) or Koichu and Kontorovich (2013). We chose this task because it is easily accessed to learners as it needs elementary mathematical knowledge and simultaneously can motivated the generation of stimulating problems (Koichu & Kontorovich, 2013; Silver et al., 1996). Furthermore, this task is appropriate for students' mathematical work in different environments, whether they include technology or not. Specifically for the current research, an applet from NCTM site was adopted for the participants who use technology. Below is the text of the task.

Imagine billiard tables as the table shown below. Assume that a ball is shot at a 45^o angle from the lower left corner A of the table. On hitting a side of the table, the ball bounces off at a 45^o angle. In the case of **Table 1** below, the ball moves on a 4×6 table and ends up in pocket B after hitting the sides 3 times. In the case of **Table 2** below, the ball moves on a 2×4 table and ends up in pocket D after hitting the side once. In each of the tables below, the ball hits the sides several times and finally lands in a corner pocket.

[1] At http://illuminations.nctm.org/Activity.aspx?id=4219

Table 2. The number of mathematical solvable problems posed by each of the research groups

Group	N	Number of problems-before	Number of problems-after
Without technology, without what-if-not	21	95	97
Without technology, with what-if-not	20	83	163
With technology, without what-if-not	19	81	158
With technology, with what-if-not	19	83	277

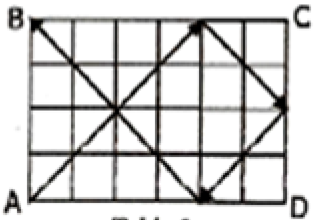

Table 1

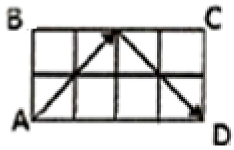

Table 2

Pose as many interesting mathematical problems on this situation as you can.

Collection and Analysis of Data

We excluded all the problems that were not mathematical or were not solvable. In this way, we excluded the problem "what happens if the table's colour is changed?" for was considered not mathematical.

Fluency in problem posing was determined based on the number of mathematical problems that a student raised and that fitted the requirement of the given task. To compute fluency in the context of the Pool Paper task, we considered every problem posed by the student, checking whether it satisfied two conditions: it was a mathematical problem and it was solvable. We added one point to the student's fluency for every problem posed that satisfied both conditions. The current research is interested in two types of flexibility for students: problem types and posing strategies. We computed the two types of flexibility by counting the number of problem types and the number of problem strategies respectively. The originality score of the participants was computed by counting the number of problems that were not suggested by any of the other participants. The method followed in the current research for analysing the three components of creativity in the context of problem posing agrees with Kontorovich et al. (2011). Using this method, all participants' answers were coded independently by the two researchers. We used Cohen's kappa to measure the agreement between the two raters (Cohen, 1960). Interrater reliability for fluency component was 92.8%, for flexibility component of problem types 89.1%, for flexibility component of strategies 88.8%, and for originality component 92.6%. The high agreement percentages between the two raters suggest that this agreement is good, and therefore, this reliability is satisfactory for each of the components of creativity.

It should be noted that studies in mathematical creativity use different and similar methods to compute the three components of creativity (fluency, flexibility and originality). Generally, researchers, as Leikin and Lev (2013) suggest computing fluency by counting the number of given problems/solutions. Methods of computing flexibility vary. Leikin and Lev (2013) suggest a specific method to compute flexibility (giving 10 points for different problem/solution categories, 1 point for a problem/solution that belongs to a previous category, but has a clear minor distinction from the other problems/solutions previously considered, and 0.1 point for a problem/solution that is almost identical with a previous problem/solution). To compute originality, Leikin and Lev (2013) suggest a relative method, in which a student's problem/solution is compared to the rest of students' problems/solutions, and the unconventional problem/solution is given 10, the partly unconventional problem/solution is given 1, while the conventional solution is given 0.1. On the other hand, Shriki (2013) suggests methods to compute fluency and flexibility that are similar to the methods that the present research uses. At the same time, to compute originality, she suggests a relative method, giving points only to students who gave problems/solutions that only third of the students suggested. We follow Kontorovich et al. (2011) in computing students' fluency, flexibility and originality, for the present research studies the same mathematical situation that they studied (see above for detailed description).

We used paired-sample t-test for investigating the significance of the score difference between the post-test and the pre-test of each of the three creativity components. In addition, we used an ANCOVA test to investigate the significance of the score differences between the creativity of the four groups as a result of using the tools. When the ANCOVA test yielded a significant F, we performed the post hoc test.

Table 3. Means and standard deviations of participants' fluency in the four groups

Group	N	Before experiment M (SD)	After experiment M (SD)	95% CI for Mean Difference	t value	Sig.	df
Without technology, without what-if-not	21	4.52 (0.74)	4.62 (0.81)	-0.63, 0.43	-0.39	0.70	20
Without technology, with what-if-not	20	4.15 (0.78)	8.15 (2.39)	-5.23, -2.76	-6.77	0.00	19
With technology, without what-if-not	19	4.24 (0.81)	8.32 (2.38)	-5.52, -2.64	-5.97	0.00	18
With technology, with what-if-not	19	4.35 (0.85)	14.58 (3.31)	-11.85, -8.61	-13.28	0.00	18

***<.000

RESULTS

Responses (Problems) Posed by the Participating Pre-service Teachers

Table 2 shows the number of mathematical solvable problems posed by each of the four groups that participated in the research before and after the experiment.

Table 2 shows that before the experiment, all the groups posed relatively the same number of problems, but after the experiment the group who used the combination of the tools posed relatively more problems than each of the other three groups.

We will next answer the two research questions. The first research question asked whether the use of different tools results in significant differences in pre-services teachers' creativity in problem posing, in each research group, before and after the use of these tools. Below we answer this question for each creativity component.

Fluency in Problem Posing Before and After the Use of Tools

As noted above, fluency in problem posing denotes the number of solvable mathematical problems posed by each student. Below are some examples from the posed problems, chosen randomly from problems that ask about the pocket in which the ball falls:

In which pocket does the ball fall in a table of 5×6? In which pocket does the ball fall in a table of q×p? In which pocket does the ball fall in a table of q×(q+1)?

Table 3 presents the scores means and standard deviations of participants' fluency in the four participating groups before and after the experiment, as well as pair-sample t-value that compares the two means of each group.

The results of the paired-sample t-test pointed out that there was a significant difference between the mean scores of fluency before and after the experiment in the three experiment groups, but no significant difference was obtained for the control group (p=0.70).

Flexibility in Problem Posing Before and After the Use of Tools

We computed flexibility in two ways: calculating the number of different types of problems posed by a participant, and calculating the number of different strategies used in posing the problems.

Flexibility-related-to-problems before and after the use of tools

As to participants' flexibility-related-to-problems, we found that the participants posed ten types of problems: about the ball's path, about the hits' number, about the angle, about the ball's speed, about the pocket in which the ball falls, about the balls' number, about the table dimensions, about the pockets' number, about two of the above issues, and about three of the above issues. Below are some examples of the posed problems, chosen randomly from all the categories. The problems were posed by the group that combined the two tools, in which all the problem types appeared.

What is the path of the ball if it begins from pocket C? What is the highest number of hits until the ball falls into a pocket? What is the angle that we need to use for the ball for it to fall into pocket B? What happens three balls are thrown? What is the number of balls if the speed of the ball increases? What are the dimensions of the table if the number of hits is five? How should the ball be launched in **Table 1** and **Table 2** in order for it to fall in pocket B? What path does the ball have if the number of pockets is eight? Describe the relationship between the measure of

Table 4. Means and standard deviations of participants' flexibility with regard to types of problems in the four groups

Group	N	Before experiment M (SD)	After experiment M (SD)	95% CI for Mean Difference	t value	Sig.	df
Without technology, without what-if-not	21	2.41 (0.81)	2.33 (0.48)	-0.43, 0.53	0.31	0.76	20
Without technology, with what-if-not	20	2.27 (0.78)	4.05 (1.19)	-2.46, -1.10	-5.49	0.00	19
With technology, without what-if-not	19	2.38 (0.83)	4.16 (1.30)	-2.5, -1.06	-5.17	0.00	18
With technology, with what-if-not	19	2.35 (0.75)	7.11 (0.81)	-5.33, -4.18	-17.25	0.00	18

Table 5. Means and standard deviations of students' flexibility with regard to strategies in the four groups

Group	N	Before experiment M (SD)	After experiment M (SD)	95% CI for Mean Difference	t value	Sig.	df
Without technology, without what-if-not	21	1.98 (0.63)	1.95 (0.59)	-0.34, 0.39	0.16	0.88	20
Without technology, with what-if-not	20	1.86 (0.45)	2.00 (0.46)	-0.44, 0.16	-0.99	0.34	19
With technology, without what-if-not	19	1.85 (0.79)	2.32 (0.48)	-0.95, 0.1	-2.04	0.06	18
With technology, with what-if-not	19	1.88 (0.76)	2.89 (0.32)	-1.46, -0.57	-4.78	0.00	18

the angle and the pocket in which the ball falls? Describe the relationship between the table's dimensions, the angle's measure, and the pocket in which the ball falls?

Table 4 shows the mean scores and standard deviations of participants' flexibility concerning the types of problems in the four groups before and after the experiment, as well as t-value that compares the two means of each group.

The results of the paired-sample t-test showed significant differences between the mean scores of flexibility related to problem types, before and after the experiment, for the three experiment groups, but no significant difference was obtained for the control group (p=0.76).

Flexibility related to posing strategies before and after the use of tools

As to the flexibility related to strategies, we identified four strategies used by the participants to pose problems: (a) posing problems about a specific mathematical object, without changing the problem's conditions, (b) posing problems about a specific mathematical object, changing the problem's conditions, (c) posing problems about a general mathematical object, and (d) posing problems about a mathematical relation. The four groups differed in their strategy use when posing problems. Both groups that did not use technology used at most two strategies: posing problems about a specific mathematical object, without changing the problem's conditions and posing problems about a specific mathematical object, changing the problem's conditions. The group that used technology but not the what-if-not strategy used at most two strategies: posing problems about a specific mathematical object, changing the problem's conditions, and posing problems about a general mathematical object. The group that used the combination of the tools used all the four strategies mentioned above.

Below are some examples of posed problems, chosen randomly from each of the categories in the order presented above. The problems were posed by the group that combined the two tools, where all the posing strategies appeared.

What is the difference between the geometric shape generated as a result of a ball hitting the sides of the 3×4 table and the geometric shape generated as a result of a ball hitting the sides of the 5×6 table? What is the number of ball hits for a 3×5 table if the number of pockets is four? What is the number of ball hits if table length is four times its width? What relationship is there between dimensions of the table and the number of ball hits when table length is odd and width is even?

Table 5 shows the mean scores and standard deviations of the participants' flexibility with regard to the different strategies in the four groups before and after the experiment, as well as t-value that compares the two mean scores of each group.

Table 6. Means and standard deviations of students' originality in the four groups

Group	N	Before experiment M (SD)	After experiment M (SD)	95% CI for Mean Difference	t value	Sig.	df
Without technology, without what-if-not	21	0.17 (0.51)	0.19 (0.60)	-0.43, 0.38	-0.11	0.92	20
Without technology, with what-if-not	20	0.15 (0.47)	0.10 (0.31)	-0.24, 0.34	0.37	0.72	19
With technology, without what-if-not	19	0.19 (0.44)	0.68 (0.75)	-0.97, -0.07	-2.45	0.03	18
With technology, with what-if-not	19	0.16 (0.49)	0.79 (0.54)	-0.95, -0.31	-4.10	0.00	18

The above computations of the paired-sample t-test showed that there were significant differences between the two mean scores of flexibility-related-to-strategies, before and after the experiment, in the two experiment groups who used technology. No significant differences were obtained for the two groups who did not use technology ($p=0.88$ for the control group and $p=0.34$ for the group who used only what if not strategy).

Originality in Problem Posing Before and After the Use of Tools

We computed originality by calculating the number of problems posed only by a participant. We found two types of such problems: (a) those asking about an issue related to two of the following properties of the mathematical situation: dimensions, number of hits, hitting angle, and the number of corners, and (b) those asking about three of the mentioned properties. Below are some examples of problems posed (chosen from the problems posed by the research group that worked with what-if-not and with technology):

What angle measure should we use to obtain an equal number of hits for the two tables 2x4 and 3x6? How does the relationship between the number of ball hits and table dimensions change when we add four pockets to the table?

Table 6 shows the mean scores and standard deviations of the students' originality in the four groups before and after the experiment, as well as t-value that compares the two mean scores of each group.

The above computations of the paired-sample t-test showed that there were significant differences between the mean scores of the experiment groups who worked with technology, before and after the experiment. No significant differences were obtained for the groups who did not work with technology ($p=0.92$ for the control group and $p=0.72$ for the group who worked with the what-if-not strategy only).

The second research question asked whether the use of each of the tools and their combination in problem posing result in significant differences in the creativity scores among the four research groups. We answer this question for each creativity component.

Differences in Fluency in Problem Posing between the Four Research Groups

The results of the ANCOVA test (See **Table 3** for the mean fluency scores of the four groups) showed that the mean fluency scores, after the experiment, differs significantly among the four groups, with $F(3,75)=60.72$, $p<0.01$, $\eta 2 =0.71$. Cohen's standard states that the effect size is small if eta-squared is 0.02. It is medium if eta-squared is 0.06, and it is large if eta-squared is 0.14 (Cohen, 1988); therefore, the effect size we obtained is large.

The results of Scheffe post hoc test (See **Table 7**) showed that the mean fluency score of the group that used a combination of the tools was significantly higher than the other three groups ($p<0.01$), whereas the mean fluency score of the group that did not use any of the tools was significantly lower than mean score of each of the other mean groups ($p <0.01$). At the same time, the mean fluency scores of the two groups that used one tool only did not differ significantly ($p=1.00$).

Table 7. Scheffe post hoc test for fluency

Group (I)	Group (J)	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval of the Difference
1	2	-3.53	0.74	0.00	-5.65, -1.42
	3	-3.70	0.75	0.00	-5.84, -1.55
	4	-9.96	0.75	0.00	-12.10, -7.82
2	1	3.53	0.74	0.00	1.42, 5.65
	3	-0.17	0.76	1.00	-2.33, 2.00
	4	-6.43	0.76	0.00	-8.60, -4.26
3	1	3.70	0.75	0.00	1.55, 5.84
	2	0.17	0.76	1.00	-2.00, 2.33
	4	-6.26	0.77	0.00	-8.46, -4.07
4	1	9.96	0.75	0.00	7.82, 12.10
	2	6.43	0.76	0.00	4.26, 8.60
	3	6.26	0.77	0.00	4.07, 8.46

Group 1: Without technology, without what-if-not, group 2: Without technology, with what-if-not, group 3: With technology, without what-if-not, group 4: With technology, with what-if-not

Table 8. Scheffe post hoc test for flexibility of problem types

Group (I)	Group (J)	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval of the Difference
1	2	-1.72	0.31	0.00	-2.60, -0.83
	3	-1.83	0.31	0.00	-2.72, -0.93
	4	-4.77	0.31	0.00	-5.67, -3.87
2	1	1.72	0.31	0.00	0.83, 2.60
	3	-0.11	0.32	0.99	-1.02, 0.80
	4	-3.06	0.32	0.00	-3.96, -2.15
3	1	1.83	0.31	0.00	0.93, 2.72
	2	0.11	0.32	0.99	-0.80, 1.02
	4	-2.95	0.32	0.00	-3.87, -2.03
4	1	4.77	0.31	0.00	3.87, 5.67
	2	3.06	0.32	0.00	2.15, 3.96
	3	2.95	0.32	0.00	2.03, 3.87

Group 1: Without technology, without what-if-not, group 2: Without technology, with what-if-not, group 3: With technology, without what-if-not, group 4: With technology, with what-if-not

Differences in Flexibility in Problem Posing between the Four Research Groups

Differences in flexibility related to problem types between the four research groups

As to differences in flexibility in problem types (See **Table 4** for the mean flexibility related to types scores of the four groups), the results of the ANCOVA test showed that the mean score of flexibility related to problem types was significantly different among the four groups, with $F(3,75)=77.60$, $p<0.01$, $\eta 2 =0.76$. Cohen's standard indicates that the effect size is large. The Scheffe post hoc test (See **Table 8**) showed that the mean score of flexibility related to problem types of the group who combined the two tools was significantly higher than that of the other three groups ($p <0.01$), and that the mean score of the group that did not use any tool was significantly lower than that of each of the other groups ($p <0.01$). At the same time, the mean scores of flexibility related to problem types of the two groups that used one tool alone was not significantly different ($p=0.99$).

Differences in flexibility related to strategies between the four research groups

As to differences in flexibility in problem strategies (See **Table 5** for the mean flexibility related to strategies scores of the four groups), the results of the ANCOVA test showed that the mean score of flexibility regarding strategies differed significantly among the four research groups, with $F(3,75)=16.11$, $p<0.01$, $\eta 2 =0.40$. Cohen's standard indicates that the effect size is large. The results of Scheffe post hoc test (See **Table 9**) showed that the mean score of flexibility related to strategies of group that used a combination of the tools was significantly higher than the mean score of the other three groups ($p <0.01$). At the same time, no significant difference we found between the mean scores of flexibility related to strategies among the other three research groups.

Table 9. Scheffe post hoc test for flexibility of problem strategies

Group (I)	Group (J)	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval of the Difference
1	2	-0.05	0.15	0.99	-0.47, 0.38
	3	-0.36	0.15	0.13	-0.79, 0.07
	4	-0.94	0.15	0.00	-1.37, -0.51
2	1	0.05	0.15	0.99	-0.38, 0.47
	3	-0.32	0.15	0.24	-0.75, 0.12
	4	-0.90	0.15	0.00	-1.33, -0.46
3	1	0.36	0.15	0.13	-0.07, 0.79
	2	0.32	0.15	0.24	-0.12, 0.75
	4	-0.58	0.15	0.00	-1.02, -0.14
4	1	0.94	0.15	0.00	0.51, 1.37
	2	0.90	0.15	0.00	0.46, 1.33
	3	0.58	0.15	0.00	0.14, 1.02

Group 1: Without technology, without what-if-not, group 2: Without technology, with what-if-not, group 3: With technology, without what-if-not, group 4: With technology, with what-if-not

Table 10. Scheffe post hoc test for originality

Group (I)	Group (J)	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval of the Difference
1	2	0.09	0.18	0.97	-0.42, 0.60
	3	-0.49	0.18	0.07	-1.01, 0.02
	4	-0.60	0.18	0.02	-1.11, -0.08
2	1	-0.09	0.18	0.97	-0.60, 0.42
	3	-0.58	0.18	0.02	-1.11, -0.06
	4	-0.70	0.18	0.00	-1.21, -0.17
3	1	0.49	0.18	0.07	-0.02, 1.01
	2	0.58	0.18	0.02	0.06, 1.11
	4	-0.11	0.19	0.96	-0.63, 0.42
4	1	0.60	0.18	0.02	0.08, 1.11
	2	0.70	0.18	0.00	0.17, 1.21
	3	0.11	0.19	0.96	-0.42, 0.63

Group 1: Without technology, without what-if-not, group 2: Without technology, with what-if-not, group 3: With technology, without what-if-not, group 4: With technology, with what-if-not

Differences in Originality in Problem Posing between the Four Research Groups

The results of the ANCOVA test (See **Table 6** for the mean originality scores of the four groups) showed that the mean score of originality differs significantly among the four research groups, with $F(3,75)=7.22$, $p<0.01$, $\eta 2 ==0.23$. Cohen's standard indicates that the effect size is large. The results of Scheffe post hoc test (See **Table 10**) showed that the mean score of originality of pre-service teachers who worked with technology, whether with or without the what-if-not strategy, are higher than the originality score of the groups who worked without it ($p <0.01$).

DISCUSSION

Pre-service teachers, in their instruction in the mathematics classes, bring significant mathematical and pedagogical knowledge, especially to their problem posing activity (Ellerton, 2013). How could tools affect this problem posing activity? In the current research, we examined whether pre-service teachers' use of tools, specifically technology and what-if-not strategy, impacted their creativity in problem posing. To do so, we explored, following other researchers (e.g., Kattou, Kontoyianni, Pitta-Pantazi, & Christou, 2013; Silver, 1997; Sriraman et al., 2013) three creativity components: fluency, flexibility, and originality. As reported in previous studies (Behzadi & Manuchehri, 2013; NACCCE, 1999; Sophocleous & Pitta-Pantazi, 2011), the present research results indicate that technology supported the creativity of pre-service teachers in the problem posing activity (Abramovich & Cho, 2006; Christou, Mousoulides, Pittalis, & Pitta-Pantazi, 2005). At the same time, the what-if-not strategy also enriched the problem-posing activity of the pre-service teachers (Brown & Walter, 1990, 1993; Silver, 1994), and generally in their creativity (Shriki, 2013; Silver, 1997). Nevertheless, in the present research, the what-if-not strategy did not support the pre-service teachers in their flexibility related to posing strategies or originality, probably because the what-if-not strategy has the potentiality to put the learner's problem-posing activity on an exact track, which limits the use of posing strategies and their use of novel ideas. This use of novel ideas is linked to originality (e.g., Levenson, 2011; Nadjafikhah, Yaftian, & Bakhshalizadeh, 2012), so what-if-not strategy did not influence significantly the participants' originality too.

More specifically, the research findings indicate that the four participating groups differed significantly in their mean score of fluency. The group of pre-service teachers, who achieved the highest mean score, was the one that used a combination of the tools, whereas the group of pre-service teachers, who did not use any tool, achieved the lowest mean score. These results indicate the contribution of both tools to learners' problem posing. The positive effect of the what-if-not strategy was probably due to the fact that it is a tool for organizing the work in problem-posing activities (Christou et al., 2005). This organization is explicit in the specific procedure of the what-if-not strategy, where it starts with stating the givens of the problem, and continues with negating them and examining what results from this negation. At the same time, the positive effect of technology on pre-service teachers' fluency in problem posing was probably due to the dynamic affordances of technology (Lagrange, Artigue, Laborde, & Trouche, 2003; Sinclair, 2004), which encourage students' exploration of the mathematical phenomena or topic. In our case, the java applet facilitated the participants' actions of changing the table dimensions and ball speed, counting the number of hits, and showing the path of the ball. It is reasonable to argue that the applet made participants aware of the problem situation (Lombardi, 2007; Pea, 1987), in our case the problem conditions, in the same way that the what-if-not strategy did. Such awareness helped the participants pose more problems by manipulating the applet's sliders or options and thus changing the mathematical situation's conditions. Observing the results of the change supported the participants to pose more problems. These results are consistent with Lavy and Shriki (2010), who found that students working in a computerized problem-posing setting believed that their activity enriched both their mathematical content knowledge and their meta-mathematical knowledge.

We considered two types of pre-service teachers' flexibility. The first was concerned with the types of problems, while the second was concerned with the strategies used (see, for example, Kontorovich et al., 2011). The findings concerning the flexibility in types of problems are similar to those concerning fluency. In this case as well, the what-if-not strategy and technology helped organize and situate pre-services teachers' problem posing, making the participants aware of the different components of the mathematical situation and thus helping them pose problems about each these components.

Regarding flexibility in the use of strategies, technology affected positively and significantly this flexibility, while the what-if-not strategy did not. Watching different examples, while utilizing technology, helped the pre-service teachers pay attention to generalizations (Bransford, Brown, & Cocking, 2000) related to the mathematical situation, and pose problems about these generalizations. The ability to observe different examples with the help of software (the Java applet) served as a generic organizer or reorganizer of the mathematical situation (Goos, Galbraith, Renshaw, & Geiger, 2003; Pea, 1987; Tall, 1989, 2002), encouraging the pre-service teachers to use more creative strategies in posing mathematical problems related to the given situation. The inability of the what-if-not strategy to better students' flexibility-related-to-strategies is a result of the strategy leading the students in a pre-defined way to pose problems, which constrained their use of different posing strategies.

The findings of the present research also showed that the group who combined the tools showed significantly higher flexibility related-to-strategies than the three other groups. Thus, the combination of the couple of tools helped the participants use different strategies more than did either technology or the what-if-not strategy alone. This effect is probably a result of the explorative systemic variation with which pre-service teachers changed the conditions of the mathematical situation and which was facilitated by the utilization of what-if-not strategy (Silver, 1994). This utilization directed the attention of the pre-service teachers to the possibility of changing the conditions of mathematical situation systematically and encouraged them to pose problems about each of them. At the same time, the presence of technology encouraged the pre-service teachers' exploration and imagination of the different possibilities of changing the conditions, which gave rise to different posing strategies. These technology capabilities are reported in the literature, for example Sinclair (2004) pointed out that technology provides dragging functionality that enables learners to use visual reasoning and to make generalizations for problems and relationships (Sinclair, 2004).

The findings of the current research indicated that the originality of pre-service teachers who worked without technology but with a what-if-not strategy was significantly lower than that of pre-service teachers who worked with technology, whether without or with the what-if-not strategy. These findings agree with researchers' claim that technology can be a facilitator of students' creativity (e.g., Yerushalmy, 2009). These results can be explained in the same way as the results concerning the participants' flexibility in posing strategies, where the features and potentialities of technology helped them gain awareness of the different conditions of the situation, resulting in awareness of conditions not stated directly in the problem, such as the shape of the table. Furthermore, these results indicate that technology that enables dynamic investigation of mathematical ideas gives open space for students to think creatively more than tools which encourage their systemic thinking.

Kontorovich et al. (2011) found it difficult to measure the originality component of creativity because in no instances did two posed problems match. This was not the case in our design, where the posed problems did match, especially with the participants who worked with technology. This difference between the way in which the two studies measured originality is due to the different contexts in which the participating pre-service teachers worked: in groups, in Kontorovich et al. (2011), and individually, in the present study. Researchers have long emphasized the effect of context on students' learning, and especially creativity (e.g., Sriraman et al., 2013; Voica, & Singer, 2013). Voica and Singer say that problem-posing sessions constitute a simple context in which students can generate structured knowledge. Moreover, Sriraman et al. (2013) argue that novelty rests on the setting of the creative process of the learner. In addition, Amabile (1983, 1999) described the effect of social variables on motivational orientation toward creativity in general. These social variables, in our case the tools used by participants, whether they were technological or learning/teaching strategies, affected their mathematical problem posing activity, and specifically their creativity in this problem posing.

The current study followed other previous researches in mathematics education to investigate three components of creativity; i.e. fluency, flexibility and originality. Future research would study how the tools impact other components of mathematical creativity, as elaboration that has been little studied in previous mathematic education research, though it has been mentioned in some studies as one component of creativity (e.g., Kanematsu & Barry, 2016; Leikin & Lev, 2013). Furthermore, the present study investigated how tools and combination between them affect students' creativity in problem posing. Future research is needed to study this issue for other tools. It is also interesting to study the difference of students' creativity when using different tools, for example physical and virtual manipulatives.

CONCLUSIONS

Researchers in mathematics education emphasize the role of creativity in the mathematics classroom. Sarrazy and Novotna (2013) consider the ability of students to produce original solutions to new problems as one of the indicators of learning and one way that serves the teacher to assess students' conceiving of the taught mathematical concepts and relations. This implies that nourishing creativity in mathematics education is of paramount importance. Mann (2005) pointed at the need for time for creativity to develop through experience, and Silver (1997) maintained that creativity is enriched with continuous work and reflection, and is affected by instructional and experiential influences. It is therefore necessary to carefully plan the nurturing of creativity in the mathematics classroom (Palha, Schuitema, van Boxtel, & Peetsma, 2015). In the present study, we attempted to do so through problem posing which is connected to creative activity that can be sustained in structured contexts that combine between real-life artefacts and human interactions (Bonotto, 2013). The contexts in which the participants worked included technology and what-if-not strategy, while the real-life artefacts included the Paper Pool situation. We examined whether these contexts nourish the creativity of pre-service teachers in problem posing. The research results indicate that technology fosters the three types of mathematical creativity in the mathematics classroom, while the what-if-not strategy fosters fluency and flexibility-related-to-problems. These influences can be related to the tools serving to organize the investigation of mathematical ideas (Tall, 1989, 2002) and technology supporting the imagination of alternatives to the mathematical situation. Specifically, technology turns the problem-posing activity into a dynamic and an interactive one, in which students interact with a given system to conceive knowledge. The interactive environment had a positive effect on pre-service teachers' activity (Scherer & Tiemann, 2014), in our case, problem posing (Abu-Elwan, 2011).

Our results showed that the technology tool is more effective than the what-if-not strategy tool in encouraging flexibility-related-to-strategies and originality in problem posing, by enabling the participants to observe the mathematical situation and actively explore it (Lagrange & Artigue, 2009). This active observation and exploration of the mathematical situation helps the students in their mathematical learning (Lagrange et al., 2003; Zales, 1997), including their problem solving and posing. This explanation clarifies our results concerning the effective influence of technology on the participants' problem posing.

We recommend the use of technology together with the what-if-not strategy in order to enhance pre-service teachers' mathematical thinking, because this combination makes available for student's learning multiple agencies required for his/her creative acts (Sinclair, de Freitas & Ferrara, 2013).

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Application of the APOS-ACE Theory to improve Students' Graphical Understanding of Derivative

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ABSTRACT

APOS-ACE (Action, Process, Object, and Schema-Activities, Classroom discussion, and Exercises) is applied in this article to explore the teaching and learning of derivative by giving emphasis on its graphical understanding. For this purpose, a Genetic Decomposition is developed based on the outcomes of previous studies and on our personal teaching experiences. An ACE cycle is designed with the help of the Maple software and implemented on a group of freshmen Iranian students (experimental group). The outcomes of this implementation are evaluated by comparing the performance of the experimental group to the performance of another equivalent student group (control group), to which the same subject was taught in the traditional, lecture-based way. Our findings demonstrated students' who were in the experimental group shown a better understanding of the derivate compared to the control group. Therefore, such ACE cycle with Maple could be used more frequently for teaching calculus, especially derivative.

Keywords: teaching and learning, derivative, graphs of functions, tangent at a point of a graph, APOS theory, genetic decomposition, ACE cycle, Maple software

INTRODUCTION

Differential Calculus has become nowadays the core of the upper secondary school mathematics (Zandieh, 2000). At university level, it constitutes the basis for the study and better understanding of many mathematical topics, as well as of a variety of other scientific disciplines, including Physics, Economics, Engineering, etc. (Stewart, 2010).

There is a difference between the *description* of a concept, which specifies some properties of that concept and the formal concept *definition* (Giraldo, Carvalho, & Tall, 2003). In particular, Giraldo et al. (2003) noted that a commonly used description of the derivative at a point a of the domain of a function (if it exists) is that it gives the slope of the tangent line to the function's graph at the point $(a, f(a))$. We recall that another common description of the derivative is that it expresses the rate of change of the function with respect to x, while its physical meaning is connected to the speed and to the acceleration at a moment of time of a moving object under the action of a force. On the contrary, the formal definition of the derivative of $f(x)$ at $x = a$ is given by $f'(a) = \lim_{x\to a} \frac{f(x)-f(a)}{x-a}$.

Previous studies reported although students' procedural knowledge about differentiation is usually adequate, most of them have little intuitive or conceptual knowledge of the derivative (Asiala, Cottrill, Dubinsky, & Schwingendorf, 1997; Clark et al., 1997; Dominguez, Barniol, & Zavala, 2017; Ferrini-Mundy & Graham, 1994; Orton, 1983; Tall, 1993; Thompson 1994; Uygur & Özdaş, 2005). It seems that several students perform poorly because they are unable to adequately handle information given in symbolic form which represents abstract entities, for example functions, or/and they lack adequate schema or frameworks, which helps to organize and link different objects (Maharaj, 2005). The implications of such findings are a variety of representations should be used, and that students should be encouraged to engage with a flexibility of mathematical conceptions of the derivative (Andresen, 2007; Maharaj, 2010, 2013). Hähkiöniemi (2004), as well as Roorda, Vos, and Goedhart (2009) noted that growth in understanding depends on a variety of connections, both between and within representations, and also between a physical application and mathematical representations.

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Contribution of this paper to the literature

- Use of MAPLE based on APOS-ACE framework to support the visual representation of derivative in the genetic decomposition and teaching cycle.
- The ACE cycle designed was implemented on an experimental group of freshmen students. The performance of the experimental group was compared to that of an equivalent group of students of the same university attending the same Calculus course.
- The outcomes shown a clearly better mean performance and a much better quality performance of the experimental group and this indicate a strong evidence about the success of our APOS-ACE instruction of derivative.

Many calculus students are proficient in differentiating a function and finding its critical values (Baker, Cooley & Trigueros, 2000; Cooley, Trigueros & Baker, 2007). However, can students conceptualize these actions and work with them if they are not presented in equation form? Ferrini-Mundy and Graham (1994) described students' difficulties in trying to sketch the derivative of a given function presented only graphically. They found that many of them tried first to find an algebraic representation, in fact students desired to find an equation for a function given only graphically before attempting to sketch the graph of the derivative. Asiala et al. (1997), in their report on students' graphical understanding of the derivative, stated that the majority of students in their study displayed a reasonable understanding of the relationship between the slope of the tangent and the derivative. Zandieh (2000) observed that students prefer the graphical representation in tasks and explanations about derivatives. This was supported by Tall (2010) who made a strong argument for direct links between visualization and symbolization when teaching the derivative.

The APOS-ACE (*Action, Process, Object, and Schema-Activities, Classroom discussion, and Exercises*) instructional treatment of mathematics, developed during the 1990's in the USA by Ed Dubinsky and his collaborators (e.g., Asiala et al., 1996; Dubinsky & McDonald, 2001) has been applied by earlier papers for teaching and learning the irrational numbers (Voskoglou, 2012) and the polar coordinates in the plane (Borji & Voskoglou, 2016, 2017). Therefore, we refer to the above papers for the central ideas of the APOS theory, while for more details we suggest Arnon et al. (2014).

The majority of the APOS studies focused on constructing a Genetic Decomposition (GD) and analyzing students' thinking based on the GD. A few studies have focused on using the *APOS theory* and *ACE teaching cycle* in conjunction (e.g., Arnon et al., 2014). This paper reports on the application of APOS-ACE theory to the teaching of the derivative in a first year undergraduate course. The main contribution of this study is that attention is drawn to the use of MAPLE based on APOS-ACE framework to support the visual representation of derivative in the genetic decomposition and teaching cycle.

THEORETICAL FRAMEWORK

In this section the theoretical frameworks of the study (i.e., APOS-ACE) are described to frame the study.

APOS Theory

The APOS theory states that the teaching and learning of mathematics should be based on helping students to use the mental structures that they already have and to develop new, more powerful structures, for handling more and more advanced mathematics (Arnon et al., 2014). These structures include Actions, Processes, Objects and Schemas, the acronym APOS being formed by the initial letters of the above four words. A mathematical concept is first formed as an action, which is, an externally directed transformation of a previously conceived object (or objects). Action is an external conception in the sense that each step of the transformation needs to be performed explicitly and instructed by external guidance; additionally, each step operates the next, that is, the steps of the action cannot be imagined and none can be skipped (Arnon et al., 2014, p. 19).

As the individual repeats and reflects on this action it may be *interiorized* to a mental *process.* A process performs the same operation as the action, but wholly in the mind of the individual enabling him/her to imagine performing the corresponding operation without having to execute each step explicitly. If one becomes aware of a mental process as a totality and can construct transformations acting on this totality, then he/she has *encapsulated* the process into a cognitive *object*. A mathematical topic often involves many actions, processes and objects that need to be organized into a coherent framework that enables the individual to decide which mental constructions to use in dealing with a mathematical situation. Such a framework is called a *schema.* In concluding, the APOS theory considers actions, processes, objects and schemas as an individual's successive *mental constructions* in learning a mathematical topic and *interiorization*, *encapsulation* as the only *mental mechanisms* needed to build those mental constructions (Arnon et al., 2014).

For example, if one can think of a function only through an explicit expression connecting the two variables involved, then he/she is having an action understanding of functions. On the contrary, a process understanding of a function enables the individual to think about it in terms of inputs, possibly unspecified, and transformations of those inputs to produce outputs. Further, an object understanding allows one to form sets of functions, to define operations on such sets, to equip them with a topology, etc. Finally, it is the schema structure that helps to see a function in a given mathematical or real world situation. The coherence of a Schema depends on one's ability to ascertain whether the schema can be used in solving a particular mathematics problem (Arnon et al., 2014).

In the following, we report some of the studies that used APOS theory in particular for derivative. In Badillo's research (2003), the APOS theory is used for constructing a GD for derivative. This GD then used to explore teachers' understanding of derivative. The most relevant contribution was a new proposal of GD for the concept of derivative, elaborated from the proposal of Asiala et al. (1997). This GD incorporated, on the one hand, the need to integrate the meanings associated with objects derived at a point ($f'(a)$) and the derivative function ($f'(x)$) in different contexts (speed, slope of a line and rate of variation), and on the other hand, the semiotic complexity associated with the relations between $f'(a)$ and $f'(x)$. The results show that teachers' understanding of these two macro objects, $f'(a)$ and $f'(x)$, may be related to the structure of the graphical and algebraic schemas of the same, and to the associated semiotic conflicts (Badillo, Azcárate, & Font, 2011).

In Gavilan (2005), Gavilan, Garcia, and Llinares (2007a, 2007b), and Garcia, Gavilan, and Llinares (2012) the teaching of derivative is described from the point of view of the constructivism (Beth & Piaget, 1974). For this purpose, they propose an investigation based on the study of two cases of teachers of high school. The most relevant contribution of this study to the APOS theory and teacher education is that they introduced and validated empirically the notion of modeling a mechanism of construction of key knowledge in the analysis of teachers' practices and beliefs.

ACE Cycle

Dubinsky and Leron (1994) highlighted that, for each mental construction that comes out from a Genetic Decomposition (GD), one can find a computer task such that, if a student engages in this task, it is fairly likely to build the corresponding mental construction. This was a starting point to a pedagogical approach connected to the APOS theory and named as the ACE teaching circle (Arnon et al., 2014). The ACE is a repeated circle of three components: Activities on the computer, Classroom discussion, and Exercises done outside the class (Arnon et al., 2014).

In relation to Activities, the first step of the cycle, students work cooperatively in groups on tasks designed to help them to make the mental constructions suggested by the genetic decomposition. The focus of these tasks is to promote reflective abstraction rather than to obtain correct answers. This is often achieved by having students write short computer programs using a mathematical programming language (Weller, Arnon, & Dubinsky, 2009, 2011).

The Classroom Discussion, the second part of the cycle, involves small group and instructor-led class discussion, as students work on paper and pencil tasks that build on the lab activities completed in the Activities phase and calculations assigned by the instructor. The class discussions and in-class work give students an opportunity to reflect on their work, particularly the activities done in the lab. As the instructor guides the discussion, he or she may provide definitions, offer explanations, and/or present an overview to tie together what the students have been thinking about and working on (Weller et al., 2009, 2011).

Homework exercises, the third part of the cycle, consist of fairly standard problems designed to reinforce the computer activities and the classroom discussion. The exercises help to support continued development of the mental constructions suggested by the genetic decomposition (Dubinsky, Weller, & Arnon, 2013). They also help students to apply what they have learned and to consider related mathematical ideas (Dubinsky et al., 2013). The relationship between ACE cycle and Genetic Decomposition are illustrated in **Figure 1**.

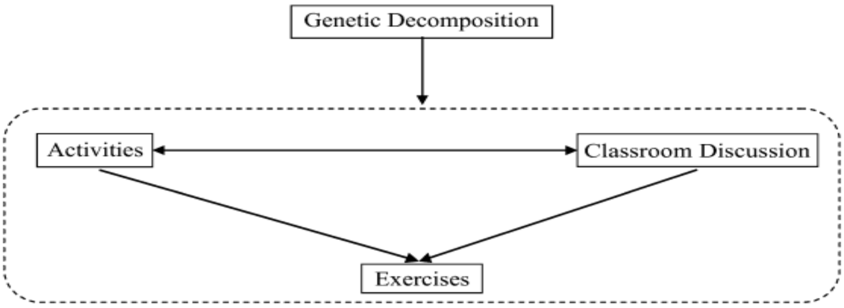


Figure 1. The ACE Cycle and its relationship to the genetic decomposition

METHODOLOGY

In Arnon et al. (2014), APOS Theory is referred as a paradigm, since:

> *"(1) it differs from most mathematics education research in its theoretical approach, methodology, and types of results offered; (2) it contains theoretical, methodological, and pedagogical components that are closely linked together; (3) it continues to attract researchers who find it useful to answer questions related to the learning of numerous mathematical concepts, and (4) it continues to supply open-ended questions to be resolved by the research community (p. 93)."*

The studies that adopt APOS as a framework used all or some of the elements of this paradigm. What we are describing as our methodology framework can be considered as a research study in which the APOS paradigm is used in mathematics education research. The methodology organized as follows: First we make a GD (the APOS theoretical analysis) for teaching and learning the derivative concept by giving emphasis to its graphical representation. Second, the corresponding ACE cycle is designed and applied on an experimental group of university students from Iran. Third, we designed a written test comprised of 4 questions to compare the performance of the experimental group with the performance of another equivalent student group (control group). The test was designed by consulting relevant resources in mathematics education, in particular the teaching and learning of derivative (e.g., Asiala et al., 1997; Cooley et al., 2007; Dominguez et al., 2017).

Participants

Two groups of university students in electrical engineering major participated in this study. At the beginning of the semester, students were divided homogeneously in two groups based on their high school math grade. In addition, to check the homogeneity of the groups, a pre-test was performed at the beginning of the semester, the results of which confirmed that both groups are homogeneous and equivalent. The pre-test questions were about the derivative (**Appendix 1**) and designed based on the high school mathematics curriculum (Research and Educational Planning Organization, 2013).

The teaching time dedicated to the concept of the derivative was equal for both groups. The only difference was the experimental group spent half of this time in the computer laboratory concentrating on writing computer programs with Maple and the rest of it in the classroom for the other teaching activities. On the contrary, the lectures to the control group were delivered on board with chalk. Power Point was also used for presenting images of functions when necessary. The same textbook (Stewart, 2010) was given to both groups. The experimental group includes 26 and the control group includes 24 students. All of them participated voluntarily in the study.

In both experimental and control groups, the teaching of the derivative focused on the graphical understanding. In the control group, all relations between a function and its derivative were explained by the lecturer on the blackboard or using PowerPoint. In detail, the lecturer used PowerPoint to describe the relationship among the graph of a function, tangent line, and the graph of the derivative function. For instance, finding the equation of the tangent line at a given point of a function presented with an algebraic form. The lecturer also showed graphically on the blackboard the followings objectives:

- The relationship between the limit of the slope of secant lines ($\lim_{x\to a} \frac{f(x)-f(a)}{x-a}$) and the slope of the tangent line at the point $(a, f(a))$.
- The relation between the derivative at a point of a graph and the value of the tangent line at that point.
- The process of sketching a graph of the derivative function of the graph of the original function.

As such, the teaching process in the control group was lecture based and students only wrote notes from on the blackboard.

Genetic Decomposition

The implementation of the APOS theory as a framework for teaching and learning mathematics involves a theoretical analysis of the concepts under study, called a *Genetic Decomposition (GD)* (Asiala et al., 1996). The following GD was designed for teaching and learning the concept of the derivative based on the previous studies (Asiala et al., 1997; Font, Trigueros, Badillo, & Rubio, 2016) and our personal teaching insights giving emphasis to its graphical understanding:

I) Definition of the derivative of a function at x using the tangent of its graph.

1. Connecting two points $A(a, f(a))$ and $B\ (b, f(b))$ on a given curve $y = f(x)$ to construct its corresponding chord and actions needed to calculate the slope $m = \frac{f(b)-f(a)}{b-a}$ of this chord.
2. Interiorization of the above actions to the process of calculating the slope of a secant line at a point *a* as the other point *b* approaches it.
3. Encapsulation of the above process in two objects, the *tangent line* at a point $(a, f(a))$ of the graph of $f(x)$ and the *slope* of the tangent, i.e. the derivative $f'(a) = \lim_{x \to a} \frac{f(x)-f(a)}{x-a}$ of the function $f(x)$ at $x = a$.

II) Sketching the graph of $f'(x)$.

4. Actions to calculate the derivative at a point $x = a$ of the domain of $f(x)$ and to plot the point $(a, f'(a))$ beside the graph of the function $f(x)$.
5. Interiorization of the actions described in step 4 to the process of calculating the derivative $f'(x)$ at any point x of the domain of $f(x)$ and of plotting the point $(x, f'(x))$ in the same coordinate system with the graph of $f(x)$.
6. Encapsulation of the above process to the object of sketching the graph of $f'(x)$ when the graph of $f(x)$ is given.

III) Organization in a coherent schema

7. When the above actions, processes and objects are organized in a coherent schema, then students become able to deal with any problems and applications concerning the graphical representation of the derivative.

Design and Implementation of the ACE Cycle

Based on the GD presented in Section 3.2 an ACE cycle for the derivative was designed. The Maple software was used in the design of the ACE. The ACE cycle was implemented on the experimental group. Before the ACE cycle, all students of experimental group attended a Maple-lab class for six hours (1.5 hours per week, for four weeks), where they had learned commands in Maple such as "plot", "pointplot", "evalf", "simplify", "seq", "subs", "limit", etc.. The ACE cycle is described in the following:

Activities on the computer

The Activities phase involves completion of cooperative series of tasks informed by the genetic decomposition. It is based on the fact that activities involving use of a mathematical programming language might be effective in helping students in learning a mathematical concept using the mental constructions called for by a genetic decomposition for the concept. Three computer activities were designed using the Maple software corresponding to three iterations of the ACE cycle. The first activity focused on a limit process, where the point $B(b, f(b))$ moving on the graph of *f(x)* approaching the fixed point $(a, f(a))$, which means that the corresponding secant line approaches the tangent line of the graph at the point A. In the second activity, students wrote a procedure in Maple designing the graph of $f(x)$ and its tangent line at $x = a,$ computing the slope of the tangent and plotting the point $(a, f'(a))$ in the same coordinate system. The third activity expanded the second one to a procedure that plots any points of the form $(x, f'(x))$ when the graph of $f(x)$ is given and designs the graph of the function $f'(x)$ in the same coordinate system.

These activities took place in a computer laboratory. The students of the experimental group were divided to smaller groups of three or four students working together. The instructor helped them when they faced problems in writing their codes, or when their codes had errors. After writing a procedure for each task, students used it for several functions and points to understand the aim of the task. The details of these three activities are described in the following:

First activity: (Related to the steps 1 – 4 of the GD)

Task 1: First, students were asked to write a procedure D_1 in Maple that receive a function and two real values a and b of its domain as inputs. The outputs were the graph of $f(x)$, the secant line through the points $(a, f(a))$ and $(b, f(b))$, and the slope of the secant line. The above procedure is written in Maple using the following commands (The explanations about these commands are provided in **Appendix 2**):

$D1 := prof(f, a, b)$

$local\ x, y, m, p1, p2;$

$m := evalf\left(\frac{f(b) - f(a)}{b - a}, 20\right);$

$y := m * (x - a) + f(a);$

$p1 := plot(\{f(x), y\}, x = a - 3..a + 2, thickness = 2);$

$p2 := pointplot([[a, f(a)], [b, f(b)]], style = point, symbol = solidcircle, color = [red, green], symbolsize = 17);$

$print(m), display(p1, p2);$

$end\ proc:$

Task 2: Next, students were asked to use the procedure D_1 for the following inputs:

a) $f(x) = x^3$, $a = 1$ and $b = 3$
b) $f(x) = x^3$, $a = 1$ and $b = 2$
c) $f(x) = x^3$, $a = 1$ and $b = 1.5$
d) $f(x) = x^3$, $a = 1$ and $b = 1.2$
e) $f(x) = x^3$, $a = 1$ and $b = 1.01$

Note that in above cases, b approaches a from the right side. The Maple outputs for this task are presented in **Figure 2**.

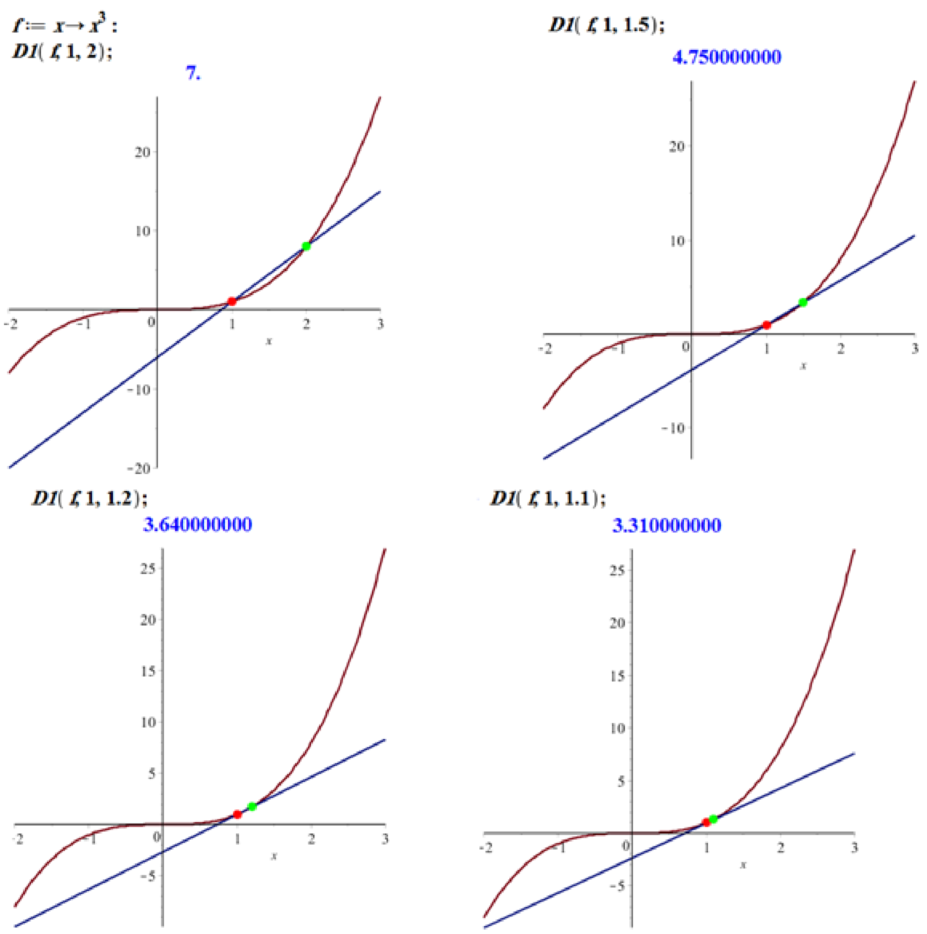


Figure 2. The outputs of task 2 for the first computer activity

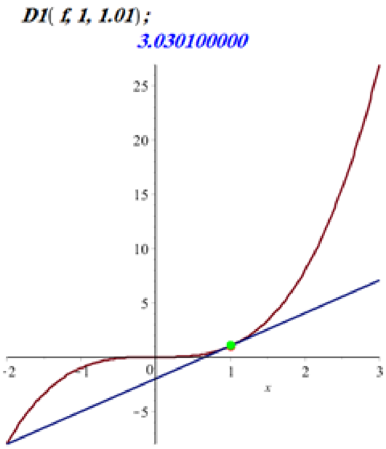


Figure 2 (continued). The outputs of task 2 for the first computer activity

Task 3: Further, students were asked to use the procedure D_1 for the following inputs:

a) $f(x) = x^3$, $a = 1$ and $b = 0$

b) $f(x) = x^3$, $a = 1$ and $b = 0.5$

c) $f(x) = x^3$, $a = 1$ and $b = 0.8$

d) $f(x) = x^3$, $a = 1$ and $b = 0.9$

e) $f(x) = x^3$, $a = 1$ and $b = 0.99$

In the above cases, b approaches a from the left side. The Maple outputs for this task are presented in **Figure 3**.

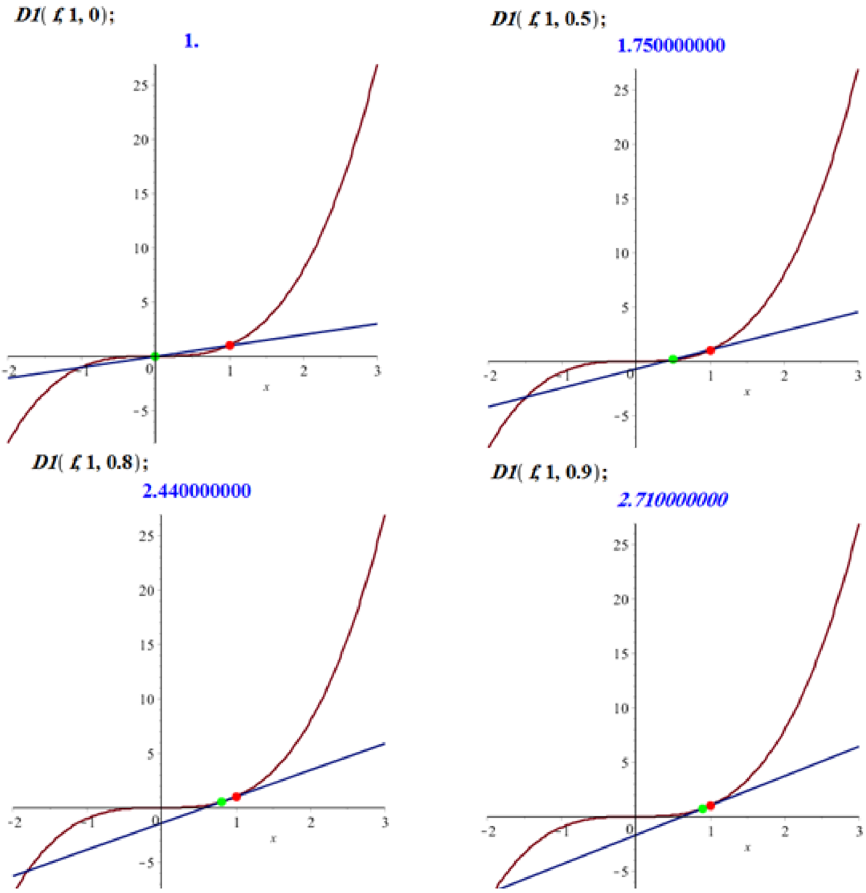


Figure 3. The outputs of task 3 for the first computer activity

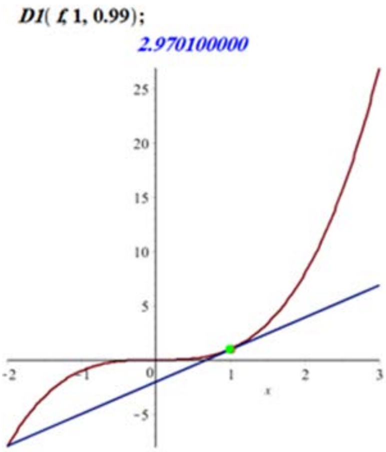


Figure 3 (continued). The outputs of task 3 for the first computer activity

The secant line in the last graphs of **Figures 2** and **3** approximates the tangent line of the graph of $y = x^3$ at $x = 1$ and therefore the value of its slope is very close to the value of the derivative $f'(1)$. In other words, the above procedure gives *a method for the approximate calculation of the derivative of a function* at a point of its domain.

At the end of this activity students were asked by the instructor to use D_1 for different functions and points of their own choice.

Second activity: (Related to the step 4 of the GD)

Task 1: The students were asked first to write a procedure D_2 in Maple that, receiving a function and a real value a of its domain as inputs, it designs the graph of $f(x)$ and its tangent line at a, it computes $f'(a)$ and it plots the point $(a, f'(a))$ in the same coordinate system. The above procedure is written in Maple as follows:

$D2 := proc(f, a)$

$local\ m, x, y, p1, p2;$

$m := limit\left(\frac{f(x) - f(a)}{x - a}\right), x = a);$

$y := m * (x - a) + f(a);$

$p1 := plot(\{f(x), y\}, x = a - 4..a + 4, thickness = 2);$

$p2 := pointplot([[a, m], [a, f(a)]], style = point, symbol = solidcircle, color = [green, blue], symbolsize = 17);$

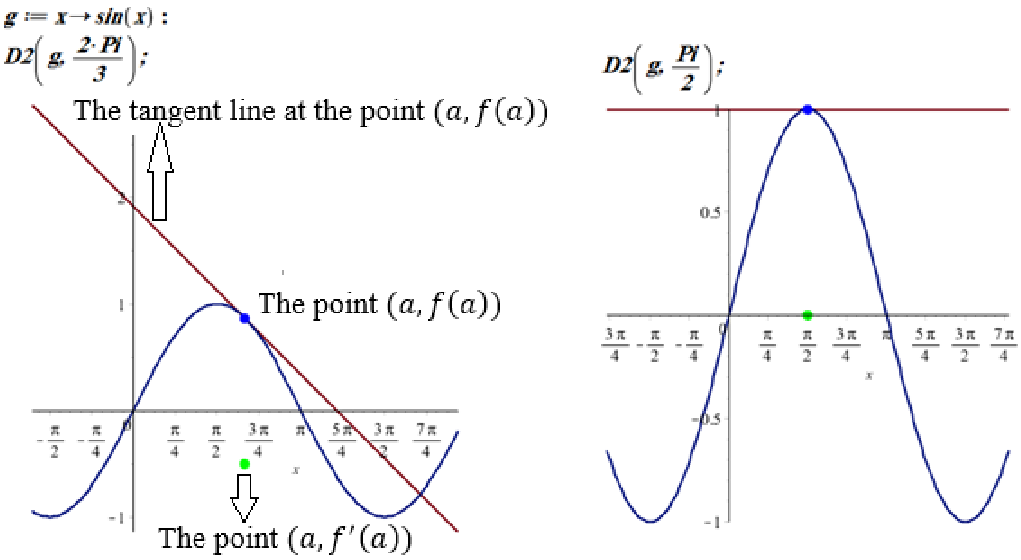
$display(p1, p2);$

$end\ proc:$

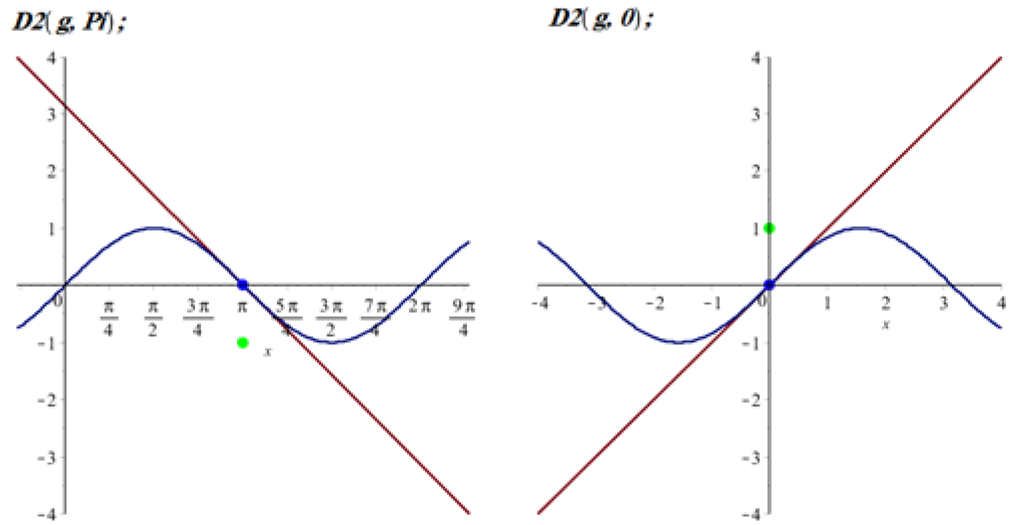
Task 2: Next the students were asked to use the procedure D_2 for inputs *sin x* and:

a) $x = \frac{2\pi}{3}$, b) $x = \frac{\pi}{2}$, c) $x = \pi$, d) $x = 0$.

The outputs of Maple for this task are presented in **Figures 4a** and **4b**.



(a)



(b)

Figure 4. (a) The outputs of task 2 for the second computer activity (cases a and b) **(b)** The outputs of task 2 for the second computer activity (cases c and d)

Third activity: (Connected to the steps 5 - 6 of the GD presented in Section 2)

Task 1: The students were asked first to write a procedure D_3 in Maple that, receiving a function, an interval $[a.b]$ contained in its domain and a positive integer n as inputs, it designs the graph of $f(x)$, it computes the values

$f'(a), f'\left(a+\frac{b-a}{n}\right), f'\left(a+\frac{2(b-a)}{n}\right) \ldots, f'(a+\frac{n(b-a)}{n})$

of the derivative and it plots in the same coordinate system all the points

$[a, f'(a)], \left[a+\frac{b-a}{n}, f'\left(a+\frac{b-a}{n}\right)\right], \left[a+\frac{2(b-a)}{n}, f'\left(a+\frac{2(b-a)}{n}\right)\right] \ldots, [a+\frac{n(b-a)}{n}, f'\left(a+\frac{n(b-a)}{n}\right)].$

The above procedure is written in Maple as follows:

$D3 := proc(f, a, b, n)$

$local\ p1, p2, x, h,$

$r := b - a;$

$df := limit(\frac{f(x+h)-f(x)}{h}, h = 0),$

$k,$

$xs := \left[seq\left(a + k * \frac{r}{n}, k = 0..n\right)\right];$

$p1 := plot(f(x), x = a..b, thickness = 4);$

$p2 := pointplot([seq([k, subs(x = k, df)], k = xs)], style = point, symbole = solidcircle, color = green, symbolsize = 15);$

$Display(p1, p2);$

$end\ proc:$

Task 2: Next the students were asked to use the procedure D_3 for:

a) The function $sin\, x$ on the interval $[0, 2\pi]$, with $n = 20$
b) The function $\cos x$ on the interval $[0, 2\pi]$, with $n = 20$
c) The function x^3 on the interval $[-3, 3]$, with $n = 20$
d) The function x^2 on the interval $[-3, 3]$, with $n = 15$

The outputs of Maple for this task are presented in **Figure 5**.

Task 3: Further, the students were asked to use the procedure D_3 for:

e) The function $sin\, x$ on the interval $[0, 2\pi]$, with $n = 200$
f) The function $\cos x$ on the interval $[0, 2\pi]$, with $n = 200$
g) The function x^3 on the interval $[-3, 3]$, with $n = 200$
h) The function x^2 on the interval $[-3, 3]$, with $n = 150$

The outputs of Maple for this task are presented in **Figure 6**.

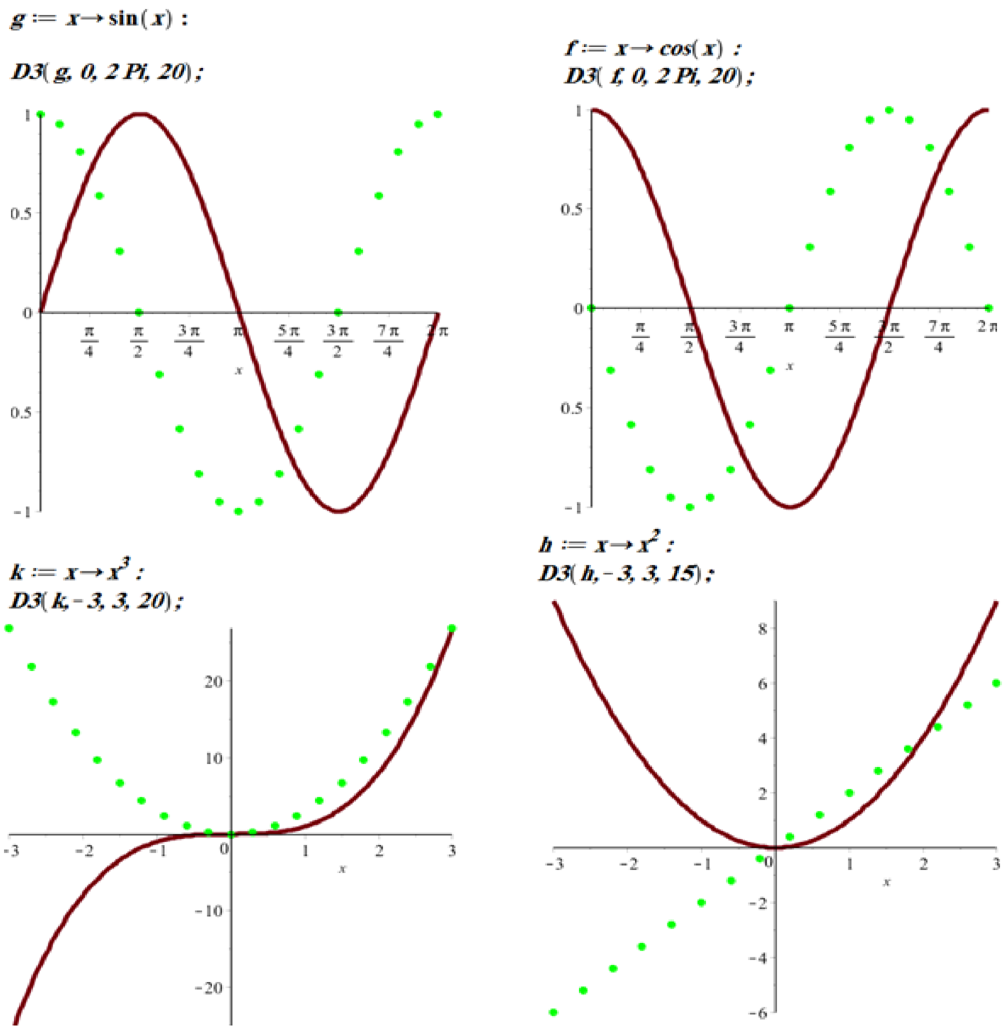


Figure 5. The outputs of task 2 for the third computer activity

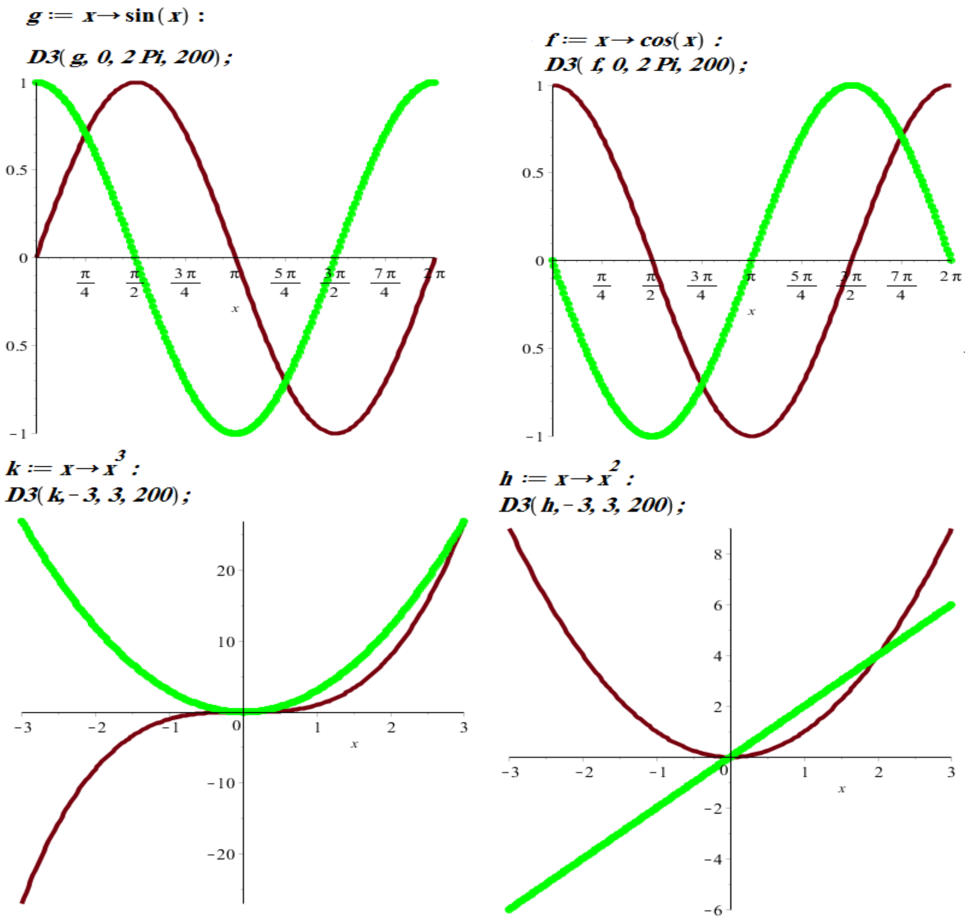


Figure 6. The outputs of task 3 for the third computer activity

At this point the instructor explained to students that the only reason for choosing the equal distribution of the points between a and b in this activity was to obtain the figures symmetrically in the outputs. In order to help students have a better understanding of this explanation students were asked to modify the procedure D_3 (see task 1), to repeat Tasks 2 and 3 by selecting the points between a and b randomly.

It should be noted that although in Activities 2 and 3 the instructor asked students to plot $f'(x)$ in the same graph as $f(x)$, in both cases, it is not necessary that students do that in the same plot as $f(x)$. If one transfer that to kinematics (or any other context), the result is that students are plotting the position and velocity values (or functions) in the same graph which is not correct. The function of position will be in terms of meters (in the vertical axis), and the function of speed will be in terms of meter/second (in the vertical axis). The use of two physical quantities in the same graph does not make sense. The class in this study is mathematics with abstract functions; however, it is crucial that students understand this issue and if possible, try to avoid it to help the transfer to contexts more easily. This is important as calculus has many applications in different disciplines (e.g., physics, engineering, and economics), and consequently, it should be treated as contextual as possible.

Classroom discussions

Each of the three computer activities was followed by a classroom discussion, where the students had the opportunity to express their ideas, thoughts, and understanding of those activities. They were also asked by the instructor to perform each activity on their papers analytically, without using the Maple. This task was given to students to have an opportunity to implement their understanding of computer activities on the paper. The highlights of students' reflections in the classroom discussions are described in **Table 1**. Examining the students' papers lead us to categorize their reflections in eight different bullet points as shown in **Table 1**.

Table 1. Students' reflections in the Classroom discussion

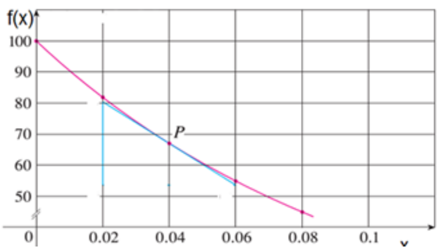
Activity	***Subject***	***Students' reflections***	**N**
1	Tangent line and the limit of the difference quotient.	• The tangent line at a point a on the graph of a function is the limit position of the sequence of secant lines through two points x and a, when the point x approaches the point a. The limit value of the slopes of these secant lines is equal to the value of the slope of the tangent line at a, which is therefore calculated by computing the $\lim_{x\to a}\frac{f(x)-f(a)}{x-a}$.	21 (80.76%)
2 & 3	The slope of the tangent line and the derivative at a point. Sketching the graph of the derivative function, when the graph of the function is given.	• The value of the slope of the tangent line at a point of the graph of $f(x)$ is equal to the value of the derivative at that point.	21 (80.76%)
		• Since the slope of the tangent line at each point of the graph of $f(x)$ is uniquely determined, the derivative of a function is also a function	18 (69.23%)
		• One can compute the value of the derivative of a function at a point of its domain from its graph by calculating the slope of the tangent line at that point. Further, computing the derivative of $f'(x)$ at an adequate number of suitably chosen points x, he/she can sketch the graph of $f'(x)$ by plotting the points $(x, f'(x))$ on the same Cartesian coordinate system.	15 (57.69%)
		• Before performing these activities, if the graph of $f(x)$ was given and we wanted to sketch the graph of $f'(x)$, we tried first to find the analytic expression of the function $f(x)$ via its graph, then we computed the analytic expression of $f'(x)$ and finally we used this expression for sketching the graph of $f'(x)$.	10 (38.46%)
		• If the graph of a function $f(x)$ is increasing / decreasing in an interval, then the graph of $f'(x)$ is above / below of the x - axis in that interval. Also, if the concavity of the function $f(x)$ is upward / downward in an interval, then the graph of $f'(x)$ is increasing / decreasing in that interval.	5 (19.23%)
		• The first part of the above remark corresponds to the well-known result that the function $f(x)$ is strictly increasing / decreasing in an interval, if, and only if, $f'(x) > 0\ (< 0)$ in that interval. Hence, $f'(x)$ is strictly increasing / decreasing in an interval, if, and only if, $f''(x) > 0\ (< 0)$ in that interval. Therefore, the second part of the above remark corresponds to the well-known result that, the concavity of the function $f(x)$ is upward / downward in an interval, if, and only if $f''(x) > 0\ (< 0)$.	5 (19.23%)

The findings reported in **Table 1** shows that a significant number of students (80.76%) understood the relation between the tangent line and the limit of the difference quotient, and they also understood that the value of the slope of the tangent line at a point of the graph of $f(x)$ is equal to the value of the derivative at that point. In addition, they understood how they can sketch the graph of f' when given the graph of f. Furthermore, five students expressed interesting remarks: "*if the graph of a function is increasing / decreasing in an interval, then the graph of $f'(x)$ is above / below of the x - axis in that interval. If the concavity of the function is upward / downward in an interval, then the graph of $f'(x)$ is increasing / decreasing in that interval*". This shows that the computer activities could help students to improve their understanding of derivative and students could find valuable relationships between the graph of a function and the graph of its derivative.

Exercises

The Exercises phase of the ACE Cycle reinforces the Activity and Classroom Discussion phases. In particular, students continued to build and expand their derivative graphical schema by working on tangent lines and the limit of difference quotients, slopes of tangent lines and derivative at different points, sketching the graph of a derivative function, when the graph of a function is given. The exercises were designed and given to students as homework and comprised different mathematics situations. Some of the exercises are described in the following.

Exercise 1 (Related to the first computer activity): Using the graph of the function $f(x)$ (**Figure 7**) and the table of its values given below, approximate the value of the derivative $f'(x)$ at $x = 0.04$.



x	f(x)
0.00	100.00
0.02	81.87
0.04	67.03
0.06	54.88
0.08	44.93
0.10	36.76

Figure 7. The data of Exercise 1

Exercise 2 (Related to the second computer activity)**:** Suppose that the line ***L*** is the tangent to the graph of the function $f(x)$ at the point (4,4) presented in the **Figure 8**. Calculate the value of $f'(4)$.

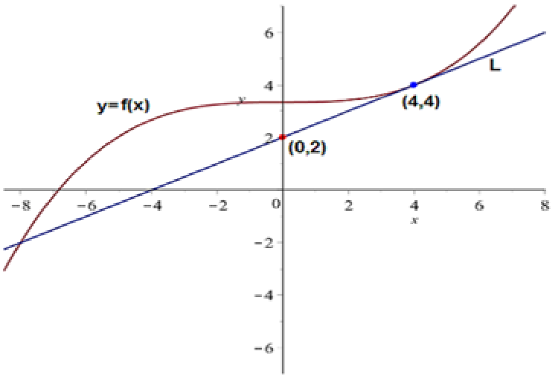


Figure 8. The graph of Exercise 2

Exercise 3 (Related to the third computer activity)**:** The graphs of two functions are given in **Figure 9**. Use them to sketch the graph of their derivatives.

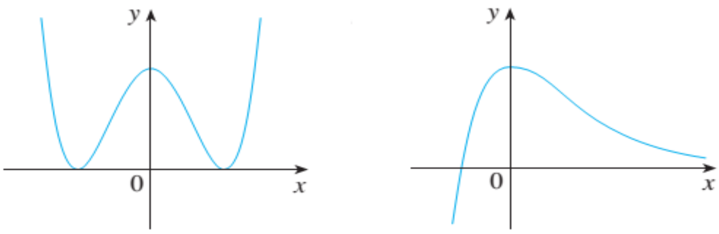


Figure 9. The graphs of Exercise 3

Students reinforced the knowledge they obtained in the computer activities and in the classroom discussions by using it in solving the exercises. In other words, it was expected that through the classroom discussions and doing homework exercises the majority of students organized the concept of derivative and in particular its graphical understanding in their proper mental schemas.

Written Test

Asiala et al. (1996) proposed a specific framework for the APOS theory based research consist of the following three components: 1) *Development of the corresponding GD (Theoretical analysis)*, 2) *Design and implementation of the proper ACE cycle (instruction)*, and 3) *Collection and analysis of the data* obtained by the implementation of the ACE cycle (**Figure 10**). The data analysis could lead to modifications of the initial GD for the mathematical topic under study.

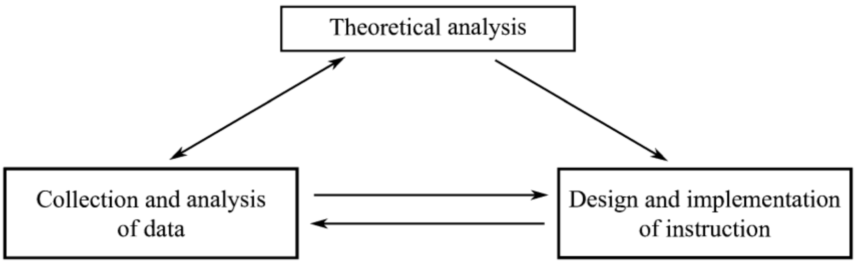


Figure 10. Research cycle (Asiala et al. 1996)

In the previous two sections we have already completed the first two components for the case of the derivative. In this section, we cover the third component. For this, the performance of the experimental group is compared to the performance of the control group.

The written test included the following four questions that are designed by the authors of this article.

Question 1: Use the given graph of f (**Figure 11**) to estimate the value of $f'(2)$.

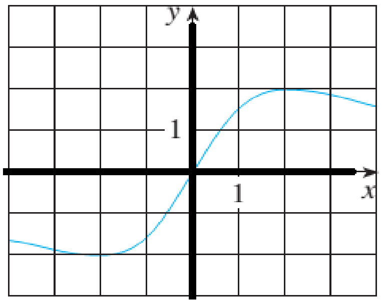


Figure 11. The graph of Question 1

Question 2: Find the points of the below graph of f (**Figure 12**) in which the function f is not differentiable and explain your reasons.

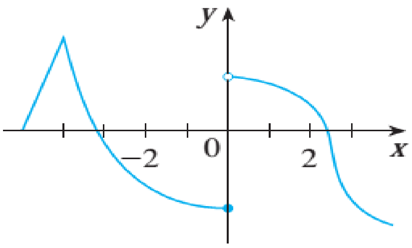


Figure 12. The graph of Question 2

Question 3: Use the values of the continuous function $f(x)$ given below (**Table 2**) to approximate the value of its derivative at $x = 2$.

Table 2. Values of y = f(x) for Question 3

X	1.9	1.99	1.999	... 2 ...	2.0001	2.001	2.1
f(x)	3.61	3.9601	3.996001	... 4 ...	4.00040001	4.004001	4.41

Question 4: The graph of a function $f(x)$ is given in the **Figure 13**. Observing that its tangent at the point $(a, f(a))$ is horizontal and its tangent at $(b, f(b))$ is vertical with respect to the x-axis, sketch the graph of the derivative function $f'(x)$.

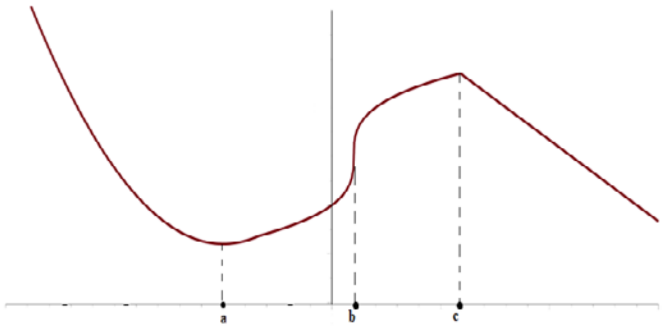


Figure 13. Graph of y = f(x) in Question 4

RESULTS OF THE IMPLEMENTATION OF THE APOS-ACE INSTRUCTIONAL TREATMENT

In this section, first, the results of the written test are presented for each question. Then, the aggregated scores for students are described.

Question 1: All students of the experimental group, except one, answered this question correctly. In the control group, 7 students failed, while the others answered correctly.

Question 2: Although the students of both groups were aware of the points where the function was not differentiable ($x = -4$ and $x = 0$), many of them, especially from the control group, did not give any explanations.

6 students from experimental and 15 students from control groups could not bring a correct reason for their answers.

Question 3: 19 students of the experimental group solved this question correctly while only 2 students of the control group succeed. Almost all students (except two of them) of the control group and some students (7 students) of the experimental group did not know the relation between the limit of difference quotient and the value of derivative at a point. For instance, one correct and one incorrect response (both from the experimental group) are shown in **Figure 14**. The incorrect response was due to a lack of prerequisite knowledge about how to find the slope of a line. This student made a mistake in using the formula for finding the slope of the lines.

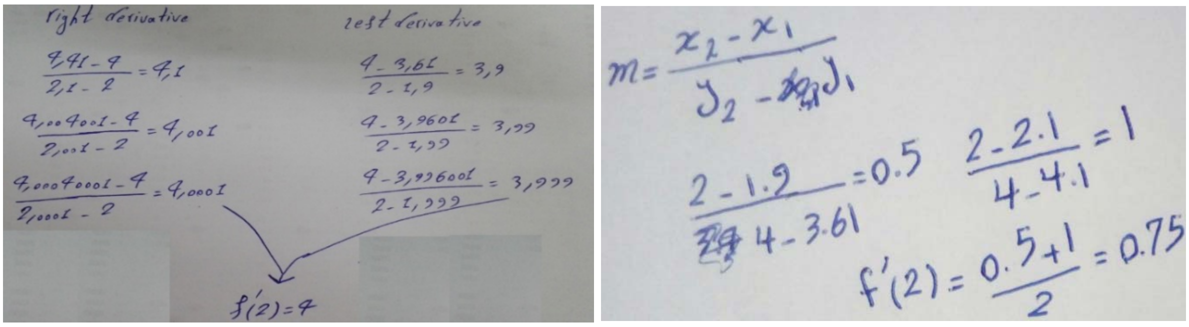


Figure 14. One correct response (left) and one incorrect response (right) to Question 3

Question 4:

Solution: Since the tangent of the given graph at $(a, f(a))$ is parallel to the x-axis, its slope is equal to zero, which means that $f'(a) = 0$. Consequently, the graph of $f'(x)$ intersects the x-axis at *a.*

Also, from **Figure 11** one observes that $f(x)$ is strictly decreasing in the interval $(-\infty, a)$, which means that $f'(x) < 0$, for all x in $(-\infty, a)$. Therefore, the graph of $f'(x)$ in $(-\infty, a)$ lies under the x-axis. Further, the concavity of $f(x)$ in $(-\infty, a)$, is upwards, which means that $f''(x) > 0$. Consequently, the derivative function $f'(x)$ is strictly increasing in $(-\infty, a)$.

In the interval (a, b), $f(x)$ is strictly increasing, therefore $f'(x) > 0$. Thus the graph of $f'(x)$ lies over the x-axis. Also the concavity of $f(x)$ is upwards, which means that $f'(x)$ is strictly increasing.

Since the tangent of the graph of $f(x)$ at $x = b$ is vertical, its slope is equal to $+\infty$, therefore there is no real value for the derivative of $f(x)$ at $x = b$, i.e. b does not belong to the domain of $f'(x)$.

Similarly, in the interval (b, c) we have that $f'(x) > 0$ and $f''(x) < 0$, i.e. $f'(x)$ is decreasing and its graph lies over the x-axis.

At the point $(c, f(c))$ the left and right tangents to the graph of $f(x)$ are different, which means that $f'(x)$ is not defined at c.

Finally, in the interval $(c, +\infty)$, $f(x)$ is strictly decreasing and its graph turns to a straight line. Therefore the value of the derivative $f'(x)$ is equal to a negative real constant at all points of this interval, which means that its graph is a straight line parallel to the x-axis and lying under it.

All the above lead to the draft design of the graph of $f'(x)$ presented in **Figure 15**.

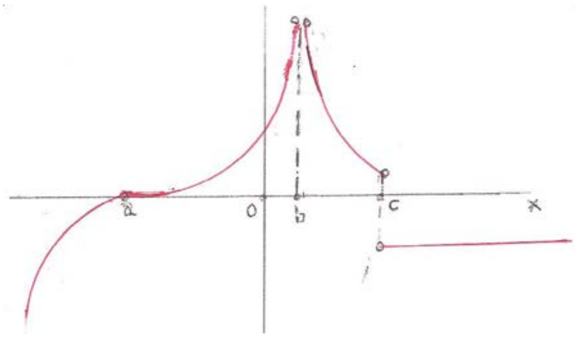


Figure 15. The graph of f′(x) in Question 4

9 students of the experimental group sketched a correct graph for the derivative function, also 9 other students of this group had a nearly correct graph but they had problems at the point x = b. None of the control group students

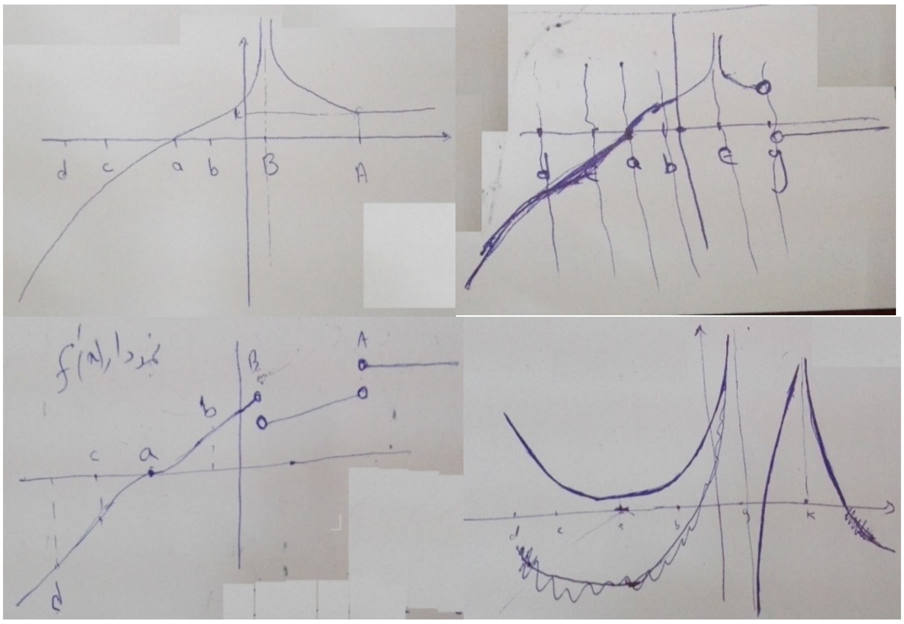


Figure 16. Student responses for Question 2

correctly answered this question. In **Figure 16** some of students' responses to Question 4 are shown. The first row is from students of the experimental, while the second row is from students of the control group.

Students' answers were marked in a score range from 0 to 10 based on a scoring system (**Table 3**) and the scores of the two groups are presented in **Table 4**.

The *mean score* for the control group was 5.33 and the mean score for the experimental group was 7.26. Therefore, the experimental group demonstrated a clearly better *mean performance* compared to the control group. Considering the results of each question and the scores from both groups shows that the quality performance of the experimental group was much better than that of the control group. It should be said here, in regards to calculating and using scores of the students in both experimental and control groups, we do not want to link them to the students' mental constructions. We only used this data to explore the effects of our ACE teaching cycle by comparing the scores of the experimental and control groups.

Table 3. Scoring system

Question	Total Score	Score system
Question 1	1	If student estimate $f'(2)$ correctly (score 1).
Question 2	2	• Function at $x = -4$ is not differentiable (score 0.5) and its reason (score 0.5). • Function at $x = 0$ is not differentiable (score 0.5) and its reason (score 0.5).
Question 3	3	• Computing left derivative at $x = 2$, $f'_-(2)$, (score 1). • Computing right derivative at $x = 2$, $f'_+(2)$, (score 1). • Computing derivative at $x = 2$, $f'(2)$, (score 1).
Question 4	4	• Sketching $f'(x)$ on $(-\infty, a]$ correctly (score 1). • Sketching $f'(x)$ on $[a, b]$ correctly (score 1). • Sketching $f'(x)$ on [b, c] correctly (score 1). • Sketching $f'(x)$ on $[c, +\infty]$ correctly (score 1).

Table 4. Scores of the control and the experimental group

Scores	10	9	8	7	6	5	4	3	2
Frequency for the control group	0	1	4	3	4	4	3	3	2
Frequency for the experimental group	4	5	4	5	3	2	1	1	1

DISCUSSION AND CONCLUSION

APOS theory has been used in several studies on calculus concepts (Badillo et al., 2011; Baker et al., 2000; Borji & Voskoglou, 2016), however, ACE has been less widely used. The majority of previous APOS research, focused on exploring students' understanding of a concept rather than how the teaching can impact on students' understanding. This lack of use of the ACE cycle in APOS research, motivated us to use APOS and ACE in conjunction to explore the teaching and learning of derivative. The main contribution of the present study to the mathematics education literature with respect to the already reported work on the subject is the use of the MAPLE software based on ACE cycle to teach and enhance students' understanding of the derivative.

Derivative was chosen because the majority of students can solve a routine differentiation problem easily, but not developed a correct conceptual understanding of derivative's graphical representation, and the relationship between the algebraic and graphical representation (Asiala et al., 1997; Baker et al., 2000; Clark et al., 1997; Sahin, Erbas, Yenmez, 2015). According to these studies as well as our personal teaching experiences, several students have not developed a deep conceptual understanding of the derivative's graphical representation.

The ACE cycle designed in this study was implemented on an experimental group of freshmen students of an Iranian university attending a single variable Calculus course. The performance of the experimental group was compared to that of an equivalent group of students of the same university attending the same Calculus course during the semester (control group). The concept of the derivative was presented to students of the control group in the traditional, lecture-based way, using only the board and Power Point projections.

We found interesting results about difficulties and misunderstandings of the students in relation to derivative based on student responses to the test questions, especially for the control group. Some students did not know the relationship between the value of the derivative at a point, $f'(a)$, and the value of the tangent line at that point, $x = a$ (Question 1). Students could not explain why the graph of f is not differentiable in some points (Question 2). If a function is not presented in equation form, and the values of the function are presented in a Table (Question 3) many students cannot estimate the value of the derivative at a point with the use of the data from that table and with the use of the limit of the sequence of difference quotients, $\frac{f(b)-f(a)}{b-a}$ (Badillo et al., 2011; Sánchez-Matamoros, Fernández, & Llinares, 2015). Furthermore, this difficulty is seen when the function is only presented graphically (Question 4) and students had to sketch the graph of the derivative function (Borji, Font, Alamolhodaei, & Sánchez, 2018). In our case, most students of the control group had fundamental problems in sketching the graph of f' (Ferrini-Mundy & Graham, 1994).

The outcomes of our experiment shown a clearly better mean performance and a much better quality performance of the experimental group and this shows the success of our APOS-ACE instruction. Based on the obtained results in relation to the graphical representation of the derivative, we believe that our instructional treatment (ACE cycle) can be used by teachers and lecturers who involve in teaching this topic. However, further research is necessary to design appropriate teaching activities using APOS-ACE framework with the help of technology (e.g., Maple) to improve students' understanding of other mathematical concepts.

Although the objective of teaching derivative in both groups focused more on graphical understanding, the results showed that the students in the experimental group achieved a deeper understanding of derivative. Examining of students' responses in the experimental group showed that it seems a significant number of them (13 students) had made a coherence schema which let them determine which intuition to use in solving the test questions. Students in the experimental group performed better than those from the control group. We believe this might be due to the following reasons: Writing computer programs with Maple helped students in the experimental group to develop their geometric interpretation of derivative in their mental constructions (Weller et al., 2009). This was one of our goals in designing and implementing the ACE cycle. It is also convenient for our purposes that APOS theory is a constructivist theory (Arnon e al., 2014). In the experimental group, the students worked in groups with their classmates and it helped them to learn from each other. Sometimes students learn better from their classmates as they are in the same grade. Students can speak about their difficulties more easily with their peers compared to their teacher. This opportunity was not possible in the classroom for the control group, where most class time was reserved for the teacher talking and writing on the blackboard, and students only took notes from blackboard. As such, in the control group the students did not have an active role in the teaching and learning processes.

There were some unsuccessful responses of the students of the experimental group. Three students had a very weak mathematical foundation. They had some difficulties in prerequisite concepts for learning the derivative (e.g., the formula of the slope of a line, finding the equation of a line with two points on the line or with one point on the line and its slope, or function and limit concepts). ACE cycle helped many of the students of the experimental group to improve their problem solving skills and to come to a higher level of learning of the derivative. In addition, some students of the experimental group who gave incorrect responses to the written test, were not active in their groups and did not participate in classroom discussions. This might be because of the personality of these students, which makes them not to speak in the presence of the teacher and their classmates as they were shy. Teachers should identify students with such personality and motivate them to participate in classroom discussions and activities. Creating a friendly and collaborative atmosphere in classroom that everyone should respect others might motivate all students to participate in classroom discussions and activities.

Teachers and lecturers have a very important role in teaching mathematics. They should be aware of the importance of using technology (activities with computers) in the teaching and learning (Blyth & Labovic, 2009; Samkova, 2012). In addition, they should be familiar with mathematical software programs and technologies (e.g., Maple) in order to be able to design teaching activities that improve students' understanding, and also encourage students to use technologies to enhance their learning. There are several studies that show that the use of technology improves students' understanding of mathematical concepts (Abu-Naja, 2008; Chamble, Slough, & Wunsch, 2008; Lyublinskaya & Zhou, 2008; Merriweather & Tharp, 1999; Ng, Tan, & Ng, 2009; Özmantar, Akkoç, Bingölbali, Demir, & Ergene, 2010). In addition, the National Council of Teachers of Mathematics (NCTM, 1989) also recommended teachers to use technology to design new teaching activities (e.g., design graphical representations with the use of mathematical software).

Furthermore, teachers and lecturers should be aware of the diversity of representations, especially graphical representation, of the mathematical concepts (Pino-Fan, Font, Gordillo, Larios, & Breda, 2017). The use of different representations (graphical, algebraic, symbolic and etc) in teaching and learning Calculus concepts and transition between these representations will help students to acquire a deeper understanding of the concepts (Breda, Pino-Fan, & Font, 2017; Mallet, 2007; NCTM, 1989; Park, 2015; Tall, 1996; Tiwari, 2007). By understanding the role of representations in teaching mathematics, teachers and lecturers would have an opportunity to design an ACE cycle that improve students' mathematical understanding.

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APPENDIX 1

Pre-test questions used to check the homogeneity of the groups

1. If $f(x) = \sqrt{x}$, find the derivative of f with respect to x.
2. Find an equation of the tangent line to the curve at the given point.

$$y = 4x - 3x^2, \qquad (2, -4)$$

3. If $f(x) = 2x^2 - x^3$, find $f'''(x)$.

The mean values of the pre-test scores were 5 for the control and 4.54 for the experimental group. Also the approximate GPA values were 0.87 for the control and 0.61 for the experimental group respectively.

APPENDIX 2

Explanations about the use of the Maple software in the classroom activities

The explanations are only provided for D_1 in the first activity as the explanations for D_2 and D_3 are similar.

$D1 \coloneqq prof(f, a, b)$ //The name of program is D1 and it receives f, a and b as input data//

$local\ x, y, m, p1, p2;$ //This line defines variables $x, y, m, p1$ and $p2$ as local variables//

$m \coloneqq evalf\left(\frac{f(b)-f(a)}{b-a}, 20\right);$ //This line evaluates the difference quotient $\frac{f(b)-f(a)}{b-a}$ to 20 decimal places and assigns it to m//

$y \coloneqq m * (x - a) + f(a);$ //This line assigns the expression $m * (x - a) + f(a)$ to y//

$p1 \coloneqq plot(\{f(x), y\}, x = a - 3..a + 2, thickness = 2);$ //This line plots graphs $f(x)$ and y on interval $[a - 3, a + 3]$ with thickness 2//

$p2 \coloneqq pointplot\big([[a, f(a)], [b, f(b)]\big], style = point, symbol = solidcircle, color = [red, green], symbolsize = 17);$ //This line plots the points $[a, f(a)]$ and $[b, f(b)]$ accompanied by options such as style, color and size//

$print(m), display(p1, p2);$ //This line shows the value of m, the graphs and the points in $p1$ and $p2$ at output//

$end\ proc:$ //End of procedure//

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Instructional Methods in STEM Education: A Cross-contextual Study

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ABSTRACT
This study contributes to an integrative view on STEM subjects from an educational point of view. The focus is on the assessment of instructional methods in relation to knowledge processes. By a questionnaire, computer science teachers and mathematics teachers assessed 20 instructional methods in terms of knowledge processes (build, process, apply, transfer, evaluate, and integrate). The findings show that computer science teachers and mathematics teachers differ on the rating of instructional methods. However, the findings also allow a common way of looking at instructional methods by computer science teachers and mathematics teachers. This is an important result for pre- and in-service training programs and for the introduction of computer science as a new school subject.

Keywords: STEM, computer science education, mathematics education, instructional methods, knowledge processes, cross-contextual research

INTRODUCTION

In recent years, national and international initiatives have emerged (Committee on Integrated STEM Education, 2014; Federal Ministry of Education and Research, 2013) to strengthen STEM (Science, Technology, Engineering, Mathematics) subjects and to improve education in STEM sub-jects. MINT is more than a list of individual subjects. In particular, MINT means interdisciplinary lessons, where the lessons are handled in its multi-perspectivity by several subjects. An essential aspect of the MINT initiatives is to build an integrative view at the participating subjects, both from a perspective of learners as well as from a perspective of teachers.

Perspective of learners. From the perspective of learners, an integrative view means that learners have understood related concepts in individual STEM subjects for solving problems (cf. Breiner, Harkness, Johnson, & Koehler, 2012; Johnson, 2013). For example, when building a wind turbine, concepts of various STEM subjects must be combined: from science concepts to capture relationships over real world facts (e.g. wind), from technology concepts to simulate a wind turbine, from engineering concepts to realize artifacts, from mathematics concepts to model real world things (e.g. wind energy) (see **Figure 1**; US Department of Energy, 2007; Windwise Education, 2018; the video of The National Academies of Science Engineering, 2018).

Perspective of teachers. From the perspective of teachers, an integrative view means that teachers offer instructional support, so learners can recognize related concepts in different STEM subjects. In this respect, one of the key questions for an integrative view of STEM subjects is: Which instructional methods most effectively support the act of learning in STEM subjects so that learners can understand the interdisciplinary concepts in STEM subjects?

For science subjects, Treagust (2007) as well as Treagust and Tsui (2014) have drawn up a rough classification of instructional methods. The classification includes seven instructional approaches: demonstration, explanation, questions, representation, analogy and metaphor, cooperative teaching, inductive / deductive approach.

For STEM subjects, STEM programs (see Committee on Integrated STEM Education, 2014, p. 145) propose to favor the instructional methods of problem-based learning and project work: “One implication of this finding is that practices such as engineering design and science inquiry, and instructional approaches like problem- and

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Contribution of this paper to the literature

- The results of the study contribute to an integrative view on STEM subjects from an educational point of view.
- The study shows that top rated instructional methods for mathematics and computer science education are problem-oriented learning, and with a lesser degree direct instruction, and project work.
- The results obtained are important for pre- and in-service training programs, especially for countries not yet having a complete teacher training course at university for computer science.

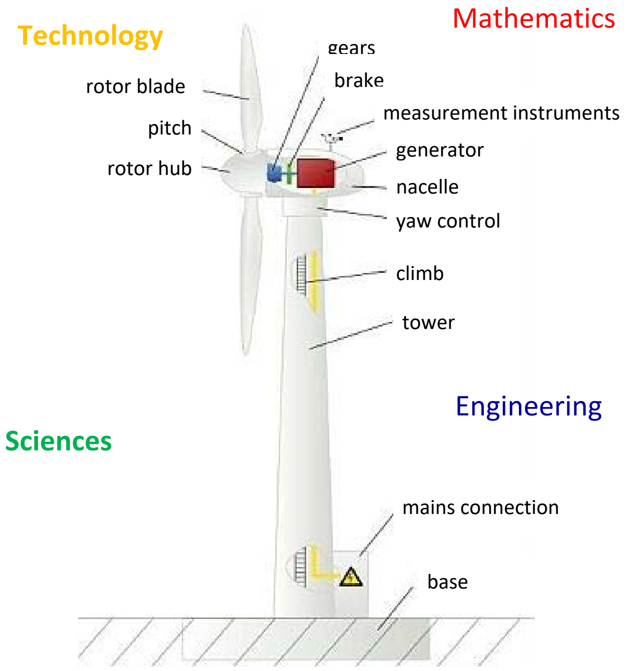

Figure 1. Integrative view at a wind turbine by STEM subjects

project-based learning, may offer special opportunities to support STEM integration when sufficient and intentional instructional support is provided."

Two STEM Subjects: Computer Science and Mathematics

The subject of mathematics was chosen because as a STEM subject it is the subject that is essential in all other STEM subjects: (1) in sciences, mathematics is fundamental for many formulas in physics, chemistry and biology, (2) in technology, mathematics assures processes to optimize artifacts, (3) in engineering, mathematics is the basis for many concepts (e.g. grammar, automata in theoretical computer science).

The subject of computer science was chosen because it is becoming increasingly important as a new subject as curricula show in different countries (European Schoolnet, 2015; Informatics Europe & ACM Europe Working Group, 2013; Ladner & Israel, 2016; The White House, 2016). Ericson (2008) cites the following reasons: (1) the assignment of the subject computer science leads to different career paths, (2) ways of thinking of computer science are important in other disciplines, (3) computer science is important for economy, (4) computer science supports other sciences and establishes connections to those, (5) computer sciences teaches problem solving both in a social and in a scientific way.

The introduction of computer science as a new school subject is a particular challenge: many more computer science teachers are needed than are currently available. One way to solve this problem is to provide specific in-service training programs for teachers that are qualified to teach computer science as a supplementary subject. Teachers who may be eligible for this may be mathematics teachers, because mathematics in part forms the roots of computer science (Becher, 1989). A necessary prerequisite for this is that mathematics and computer science teachers have a similar understanding of instructional methods, which is very important and has to be verified empirically.

Instructional Methods

The wide range of instructional methods is almost incomprehensible. The associated literature describes a broad spectrum of instructional methods ranging from methods of conveying and acquiring knowledge to management methods for games, movement, emotions, groups, health, violence and conflicts. The Center for Teaching and Learning (2018) cites 150 instructional methods, Gugel (2011) more than 2,000 methods including their variations.

There are well-prepared monographs of instructional methods available (e.g. Cruickshank et al., 2011; Petrina, 2006; Petty, 2009). The monograph from Joyce and Weil (2008) is helpful in bringing order to the variety of concepts, with classifications of the instructional methods for *teaching families* (social interaction family, information processing family, personal family, behavioral modification family).

Definitions. Meyer (2002) is a source of a very general definition stating that instructional methods are the forms and procedures by which teachers and students acquire the natural and social reality that surrounds them, taking into account the institutional framework of the school. According to this general definition of instructional method, the idea of what instructional methods mean is very uneven. In addition, a variety of synonyms exist, depending on whether instructional methods are addressed in the context of learning forms, teaching forms or teaching approaches. A narrower definition of method comes from Huber and Hader-Popp (2007, p. 3), which also provides the conceptual starting point for this article: "The word method is understood to mean a clearly defined, conceptually perceivable and independent, if also integrated, component of teaching."

Empirical findings. Numerous empirical findings on the effectiveness of learning are available. In his 800 meta-analyses into which more than 50,000 studies were included Hattie (2009) provides information on the effectiveness of learning with respect to six domains: contributions of the person learning, the parental home, the school, the instructor, the curricula and teaching. In particular, the domain of teaching (Hattie, 2009, Chapters 9 and 10) provides information on the effectiveness of instructional methods/approaches. High effect sizes (d > .50) were demonstrated for microteaching (d = .88), reciprocal teaching (d = .74), feedback (d = .73), problem solving (d = .61), direct instruction (d = .59), mastery learning (d = .58), case study (d = .57), concept mapping (d = .57), peer tutoring (d = .55), cooperative (vs. competitive) learning (d = .54), and interactive instructional videos (d = .52).

Instructional methods for computer science education. As yet no standard reference for computer science education is available which extensively addresses the application of instructional methods for school. The literature contains descriptions on the application of *solving problems* (Koffmann & Brinda, 2003), *group work* (Iron, Alexander, & Alexander, 2004), *rich tasks*, *concept-mapping* (Hazzan, Lapidot, & Ragonis, 2011), *pattern-oriented instruction* (Muller & Haberman, 2008), *lab-centered instruction* (Titterton, Lewis, & Clancy, 2010), *discovery learning and project teaching* (Hartmann, Näf, & Reichert, 2006), and *visualizations* (Fincher & Petre, 2004).

Instructional methods for mathematics education. For mathematics education a number of good standard references is available which addresses the application of instructional methods: Heddens, Speer, and Brahier (2008), Kidwell and Ackerberg-Hastings (2008), Li, Silver, and Li (2014). A variety of teaching examples with methodical focus are included in practice-oriented journals on mathematics education: e.g. *The Mathematics Educator, The Mathematics Enthusiast, Mathematics Teaching*.

Knowledge Processes Involved in the Act of Learning

The theory from Collins, Brown, and Newman (1989), which has situated learning at its core, reveals four main phases: *modeling, scaffolding, fading,* and *coaching.* Cognitive oriented approaches (Bruner, 1966; Gagné, Wagner, Golas, & Keller, 2004) link instruction to the acquisition and processing of knowledge. They emphasize three knowledge processes in the act of learning: *acquisition of new information, transformation (manipulating knowledge to make it fit to new tasks), evaluation (checking whether the way we have manipulated information is adequate to the task)* (*see* Bruner, 1966, p. 48; Gowda, 2010; Merriam & Caffarella, 2006, p. 46).

The educational literature knows numerous variations relating teaching to learning as an act spread over time and to phases, which can be distinguished during the course of learning (Bruner, 1966; Davis, 2009; Olson, 2007; Petrina, 2006). What all of the variations have in common is that learning (1) has a starting point, (2) a sequential form and (3) a (generally preliminary) end point. Educational literature describes this as the *classic three-step* pattern divided into the steps labeled *entry, work phase* and *graduation.* These three steps have particularly large distinctions in their educational functions and in the knowledge processes of the act of learning.

Particularly in the work phase, important knowledge processes (Bruner, 1966; Gowda, 2010; Merriam & Caffarella, 2006) can be distinguished in the act of learning. This indicates the processes in the acquisition of knowledge (*build, process*), in the transformation of knowledge (*apply, transfer*) and in the evaluation of knowledge (*assess, integrate*). The exact definitions of the knowledge processes are as follows:

- *build:* Acquiring knowledge, new practical and cognitive abilities as well as attitudes;
- *process:* Establishing, deepening, structuring and connecting what has been learned;

- *apply:* Using what has been learned in new tasks corresponding with the framework conditions of the learning situation;
- *transfer:* Using what has been learned in new situations in which the framework conditions differ from those of the learning situation;
- *assess:* Classifying what has been learned in regard to its usefulness, scope, benefits and limits;
- *integrate:* Integrating what has been learned outside of the actual learning situation in connection with one's own knowledge.

RESEARCH QUESTION

For computer science and mathematics education standard references on instructional methods exist (see above). However, it is insufficiently clarified which instructional methods are effective in the act of learning, especially with respect to different knowledge processes. In addition, it is unclear, which instructional methods allow an integrative view on STEM subjects from the perspective of teachers, not even in the context of only two STEM subjects. In this regard, the following research hypothesis will be investigated:

"Computer science teachers differ from mathematics teachers in their ratings of instructional methods with respect to knowledge processes in supporting the act of learning. "

In order to answer the research hypothesis, a procedure is used that is of primary interest in the context of the cross-contextual research paradigm (Berry, Poortinga, Segal, & Dasen; Lerner, Easter Brooks, Mistry, & Weiner, 2003; Saraswathi, 2003). The procedure includes answering three so-called research goals.

(1) *Transport and test goal*: Can the combinations of instructional methods and knowledge processes found in the computer science education context be generalized to the mathematics education context?
(2) *Discover variations goal*: Can other combinations of instructional methods and knowledge processes be found in the mathematics education context that are also important in the computer science education context?
(3) *Assemble and integrate goal*: Can the combinations of instructional methods and knowledge processes identified in the two contexts be integrated to generate a broader perspective that is valid for both contexts?

In the next section, we present the research methods applied, describing the study design and procedures and the data analysis strategy. Then, we give a detailed account of our findings. In the last two sections, we discuss those findings and, finally, draw implications for pre- and in-service training programs.

METHOD

Selection of Instructional Methods

The review of a series of instructional methods manuals (Cruickshank et al., 2011; Davis, 2009; Ginnis, 2001; Joyce & Weil, 2008; Petrina, 2006; Petty, 2009) revealed more than 50 instructional methods to choose from. The review was characterized by the requirement that instructional methods had to pass the muster as being capable of being understood as clearly defined, conceptually perceivable and independent components of the instruction.

The following criteria were applied for the final selection of the instructional methods: (1) The actual application of the instructional methods in computer science and mathematics education, (2) the application of the instructional methods in STEM subjects (sciences, technology, engineering, mathematics) and (3) empirically examined instructional methods. The following 20 instructional methods (in alphabetical order) were selected on the basis of these criteria:

Case study, computer simulation, concept mapping, direct instruction, discovery learning, experiment, jigsaw method, learning at stations, learning by teaching, learning tasks, Leittext method, models method, portfolio method, presentation, problem-based learning, programmed instruction, project work, reciprocal teaching, role-play, and web quest.

Process models for all 20 instructional methods have recently been developed and visualized according to a uniform schema in IDEFO (Integrated Definition for Function Modeling) (Menzel & Mayer, 2005), which make explicit the individual steps in the implementation of the instructional methods in the classroom (Zendler, 2018). **Appendix A-1** contains examples of the process models of case study, computer simulation, and concept mapping.

The hypotheses were tested in a SPF-2•20×6 split-plot design (3-factor design with repeated measures of factors *B* and *C*, see **Figure 2**; Kirk, 1994; Winer, Brown, & Michels, 1991).

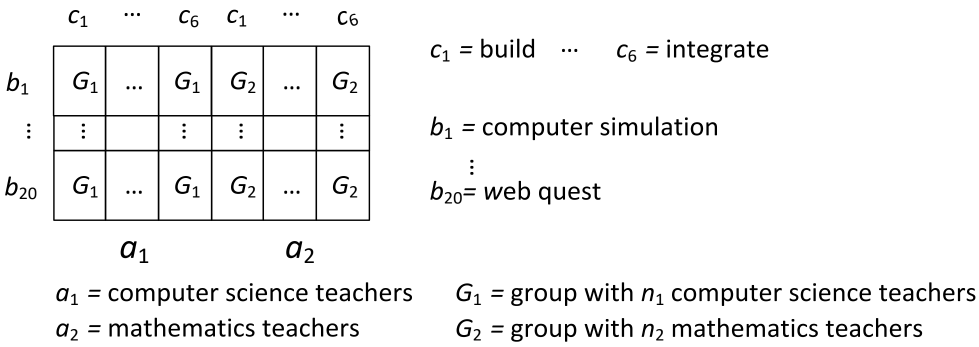

Figure 2. Experimental design

Independent variables. Factor *A* comprised the $p = 2$ groups surveyed, with factor level a_1 representing group G_1 of n_1 computer science teachers and factor level a_2 representing group G_2 of n_2 mathematics teachers. Factor *B* represented the $q = 20$ instructional methods $b_1, \ldots, b_{20}$: case study, computer simulation, concept mapping, direct instruction, discovery learning, experiment, jigsaw method, learning at stations, learning by teaching, learning tasks, Leittext method, portfolio method, presentation, problem-based learning, programmed instruction, project work, reciprocal teaching, role-play, and web quest. Factor C represents the $q = 6$ knowledge processes with factor levels $c_1, \ldots, c_6$: *build, process, apply, transfer, assess, and integrate*.

Dependent variable. The dependent variable was the respondents' rating of the instructional methods with respect to the six knowledge processes. Ratings were given on a six-point scale with ratings ranging from 0 ("not significant") to 5 ("very significant").

A power calculation of type II—*N* as a function of power $(1–\beta)$, Δ, and α—was used to determine the necessary sample size for the 2•20×6 split-plot design (Mueller & Barton, 1989; Mueller, LaVange, Ramey, & Ramey, 1992): With a power $(1–\beta)$ of 0.80, only large effects ($\Delta = 0.80$) on the dependent variable being considered significant, and a significance level of $\alpha = 0.05$, a total sample of approximately $N^* = 30$ ($n_1^* = 15$ computer science teachers, $n_1^* = 15$ mathematics teachers) would be required, based on the power computations of Mueller and Barton (1989) or Mueller, LaVange, Ramey, and Ramey (1992) for ε-corrected *F* tests.

Operational Test Hypothesis

Given the study design and the above specification of the independent and dependent variables, the operational hypothesis of the study can be formulated as follows:

"Computer science teachers differ from mathematics teachers in their ratings of instructional methods (case study, computer simulation, concept mapping, direct instruction, discovery learning, experiment, jigsaw method, learning at stations, learning by teaching, learning tasks, Leittext method, models method, portfolio method, presentation, problem-based learning, programmed instruction, project work, reciprocal teaching, role-play, web quest) in supporting the act of learning, operationalized by computer science teachers´ and mathematics teachers' ratings on a six-point scale of the knowledge processes *build, process, apply, transfer, assess and integrate*."

Sample

For the empirical study, 120 computer science teachers in 2014, and 120 mathematics teachers in 2015 at German high schools in the Federal state of Baden-Württemberg were contacted and invited to complete a questionnaire on the usage of instructional methods in computer science and mathematics education. The computer science teachers who sent back the questionnaire, taught computer science in grades 11 and 12/13. On average, they taught about 7.5 years computer science; in addition to the lessons in computer science all computer science teachers taught mathematics. Almost all mathematics teachers who sent back the questionnaire, taught mathematics grades 5 to 12/13. 20 mathematics teachers taught mathematics more than 10 years; in addition to the lessons in mathematics almost all mathematics teachers taught another STEM subject.

Questionnaire

The questionnaire consisted of a short introduction listing the 20 instructional methods and the 6 knowledge processes. The questionnaire was accompanied by a booklet for the computers science teachers (Zendler & Klaudt, 2014) and the mathematics teachers (Zendler, Seitz, & Klaudt, 2015). It describes the 20 instructional methods in accordance with a uniform scheme containing (1) a brief description and explanation, (2) concrete execution steps,

(3) and examples from the relevant literature verifying the application of the instructional method in computer science education and mathematics education, respectively. The questionnaire has been used successfully in several pro-jects and has been validated using the so-called comparative method (Zendler, Klaudt, & Seitz, 2018).

Tasks

The p = 20 instructional methods and the q = 6 knowledge processes were presented in alphabetical order in a matrix with the instructional methods in the rows and the knowledge processes in the columns. Participants were asked to indicate the relevance of each of the 20 × 6 = 120 matrix cells: Each cell represents a combination of an instructional method and a knowledge process and requires an integer from 0 ("not significant") to 5 ("very significant") indicating the relevance of the combination (see **Appendix A-2 Questionnaire**).

Return Rate

To maximize the return rate, we mailed both samples the questionnaires in sealed, personalized envelopes, enclosing a pre-addressed return envelope franked with stamps showing flower designs (see Dillman, 2000 for recommendations on increasing return rates). The return rate for the computer science teachers was 20.0% (n_1 = 24 valid questionnaires of 32 returned questionnaires), which can be considered reasonable for a postal survey (see Vaux & Briggs, 2005). The return rate for the mathematics teachers was 24.25% (n_2 = 29 valid questionnaires of 40 returned questionnaires).

Data Analysis

In analyzing our empirical data, we followed recommended procedures for cross-contextual research (Harkness, van de Vijver, & Mohler, 2003; van de Vijver & Leung, 1997). First, we conducted a three-factor analysis of variance with repeated measures in accordance with the 2•20×6 split-plot design (see Winer, Brown, & Michels, 1991, chapter 7). We conducted a posteriori comparisons of means to test for effects of the $A \bullet B$ interaction and the $A \bullet B \times C$ interaction.

Data analyses were conducted using SPSS 22.0; the power analysis was computed with PASS 13.

RESULTS

Figure 3 visualizes the mean ratings (*see* **Appendix A-3 Data**) obtained from the computer science teachers (a_1) and the mathematics teachers (a_2) for each of the 20 × 6 combinations of instructional methods × knowledge processes the (repeated measures factors $B \times C$). **Figure 3** illustrates that instructional methods in relation to knowledge processes have been rated differently by computer science and mathematics teachers. However, concrete effects are difficult to be identified. Thus, more detailed analyses are necessary in relation to the three cross-contextual research goals (*transport and test goal*, *discover variations goal, assemble and integrate goal).*

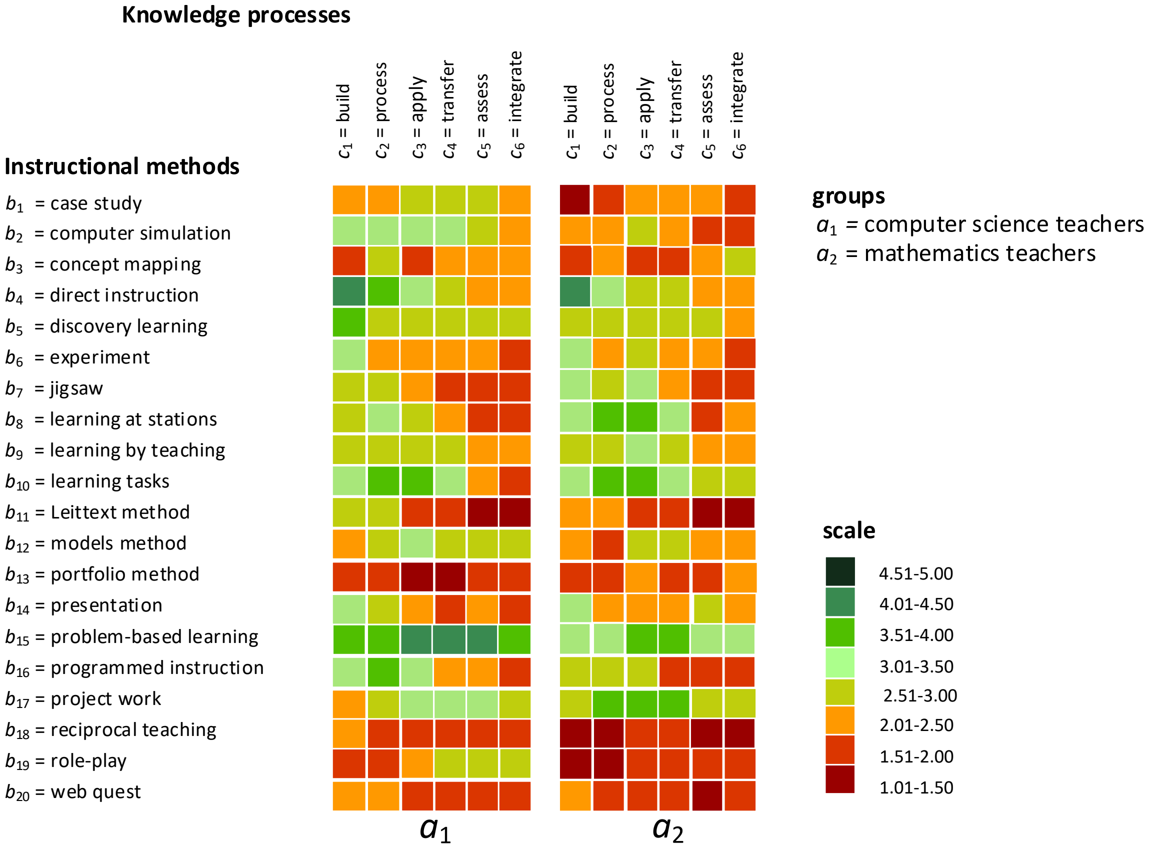

Figure 3. Mean ratings (alphabetically sorted)

Findings for the *Transport and Test Goal*

To examine whether the combinations of instructional methods and knowledge processes identified in the computer science education context can be generalized to the mathematics education context, we formulated three statistical hypotheses, which were tested at the significance level of $\alpha = 0.05$.

Statistical hypotheses. The three null hypotheses were as follows:

i) the means of the instructional methods μ_1 under a_1 (computer science teachers) and μ_2 under a_2 (mathematics teachers) are equal, such that:

$$H_0\colon \mu_1 = \mu_2$$

ii) the means of the instructional methods $\mu_{1\bullet 1}, \mu_{1\bullet 2}, \ldots, \mu_{2\bullet 20}$ under the $2 \bullet 20$ levels of the factor combinations $A \bullet B$ are equal, such that:

$$H_0\colon \mu_{1\bullet 1} = \mu_{1\bullet 2} = \ldots = \mu_{2\bullet 20}$$

iii) the means of the instructional methods $\mu_{1\bullet 1\times 1}, \mu_{1\bullet 1\times 2}, \ldots, \mu_{2\bullet 20\times 6}$ under the $2 \bullet 20{\times}6$ levels of the factor combinations $A \bullet B \times C$ are equal, such that:

$$H_0\colon \mu_{1\bullet 1\times 1} = \mu_{1\bullet 1\times 2} = \ldots = \mu_{2\bullet 20\times 6}$$

Testing the statistical assumptions. For an analysis of variance of a split-plot design, the data must satisfy the condition of sphericity. This assumption was tested using Mauchly's W test for sphericity, with the test statistic W being compared to a chi-square distribution to assess the adequacy of the sphericity assumption. The assumption of sphericity was not met for either the instructional methods (W=0.001, $\chi^2_{189} = 369.27$, $p < 0.001$) or the knowledge processes (W=0.372, $\chi^2_{14} = 48.61$, $p < 0.001$) at the α level of 0.05. In the further analyses, we therefore applied the ε correction of degrees of freedom proposed by Huynh and Feldt (1976).

The main effect A (computer science teachers vs. mathematics teachers) was *not* significant at the α level of 0.05 ($F_{1,51}$= 0.54, $p < 0.47$). The corresponding H_0 was therefore *not* rejected: computer science teachers and mathematics teachers did not differ in their *global* ratings of the instructional methods.

Table 1. Analysis of variance

Source of variation	*SS*	*Df*	*MS*	*F*	*p*	*η2*
between subjects						
A	23.61	1	23.61	0.54	< 0.47	< 0.011
error (A)	2233.49	51	43.97			
within subjects						
A • B	200.47	13	15.47	2.12	< 0.02	< 0.040
error (B)	4831.66	661	7.31			
A • B × C	84.40	34	2.38	0.90	< 0.65	< 0.017
error (B × C)	4800.16	1734	2.76			

The interaction effect *A • B* (group • instructional methods) was significant at the α level of 0.05 ($F_{13, 661} = 2.12$, $p < 0.02$). The corresponding H_0 was therefore rejected: computer science teachers and mathematics teachers differ in their ratings of *individual* instructional methods.

The interaction effect *A • B × C* (group • instructional methods × knowledge processes) was *not* significant at the α level of 0.05 ($F_{34, 1734} = 0.90$, $p < 0.65$). The corresponding H_0 was therefore *not* rejected: computer science teachers and mathematics teachers did not differ in their ratings of *individual* instructional methods with respect to *individual* knowledge processes.

In summary, our findings for the *transport and test goal* indicate that the combinations of content and process concepts identified by the computer science teachers can not totally be generalized to the mathematics education context.

Findings for the *Discover Variations Goal*

To examine the discover variations goal, two examinations have to be conducted. (1) On the one hand, it must be tested whether computer science and mathematics teachers differ in their ratings of *individual* instructional methods. (2) On the other hand, it must be tested in more detail whether computer science and mathematics teachers differ in their ratings of *individual* instructional methods in relation to *knowledge processes*.

1. Individual comparisons for the *A • B* interactions. To examine whether it was possible to identify combinations of instructional methods in the mathematics education context that are also relevant in the computer science education context, we conducted mean comparisons of the group • instructional methods combinations. These comparisons were conducted using *t* tests to evaluate simple $\overline{AB}$ effects for $p \bullet q \times r$ split-plot designs (Winer, Brown, & Michels, 1991, pp. 535–536), account taken of the ε correction of degrees of freedom ($df = df_{error\ (A)} + df_{error\ (B)} = 51+661=712$; see **Table 1**) for the *t* tests.

Figure 4 visualizes the means and standard errors of the *A • B* interactions for the computer science teachers and the mathematics teachers for each instructional method. The strength of the *simple* $\overline{AB}$ *effects* are visualized and the corresponding *p*-values can be identified by using the *scale of simple* $\overline{AB}$ *effects.* The results of the individual comparisons show that the computer science teachers (a_1) and the mathematics teachers (a_2) differ significantly in their ratings of instructional methods at the α level of 0.05. They differ in the ratings of the following instructional methods:

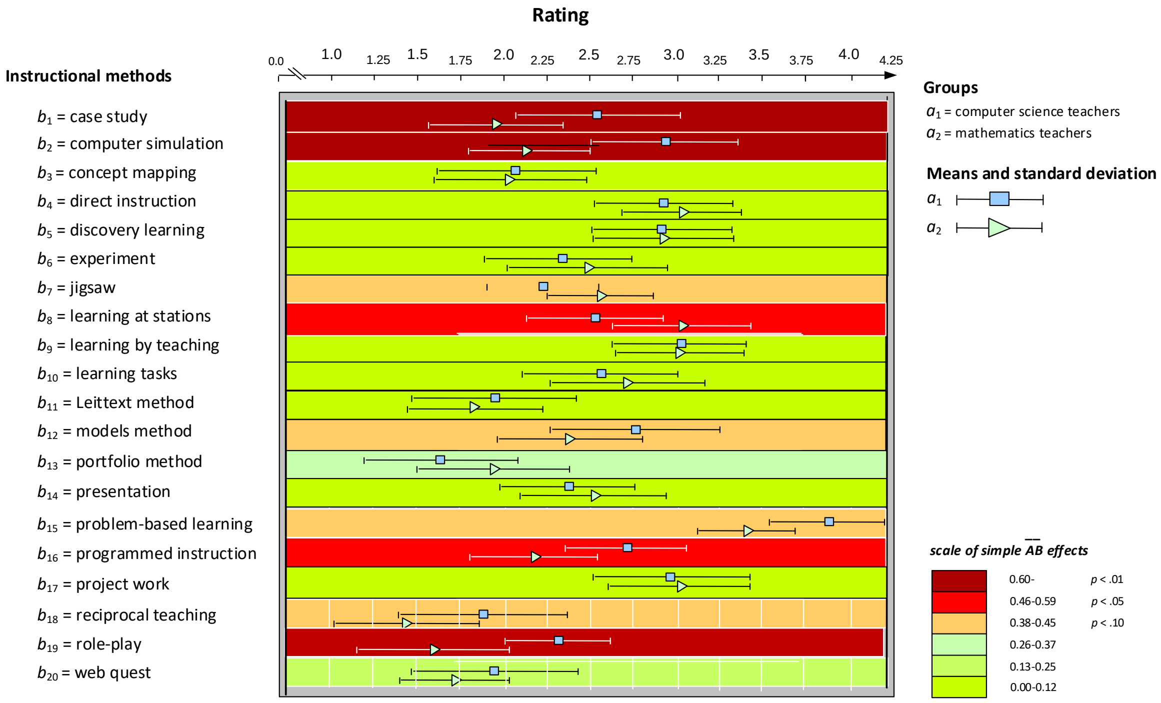

Figure 4. Individual comparisons (A • B interactions)

- case study (is rated higher by computer science teachers);
- computer simulation (is rated higher by computer science teachers);
- learning at stations (is rated higher by mathematics teachers);
- programmed instruction (is rated higher by computer science teachers);
- role-play (is rated higher by computer science teachers).

2. Individual comparisons for the A • B × C interactions. We next conducted a posteriori pairwise mean comparisons to test which group • Instructional method × knowledge process combinations differed significantly, using 20 × 6 = 120 t tests to evaluate simple $\overline{ABC}$ effects for $p \bullet q \times r$ split-plot designs (Winer, Brown, & Michels, 1991, pp. 535–536), account taken of the ε correction of degrees of freedom ($df = df_{error\ (A)} + df_{error\ (B)} + df_{error\ (C)} + df_{error\ (B\times C)} =$ 51+661+202+1734=2648 – see **Table 1**) for the t tests. Given the number of t tests that had to be conducted, an adjusted α level was used to determine statistical significance.

Figure 5 shows that computer science teachers and mathematics teachers differ significantly in their ratings of *individual* instructional methods with respect to *individual* knowledge processes. The figure illustrates *simple* $\overline{ABC}$ *effect*s for each *instructional* method with respect to *individual* knowledge processes. The strength of the *simple* $\overline{ABC}$ effects are visualized and the corresponding p-values can be identified by using the *scale of simple* $\overline{ABC}$ *effects*.

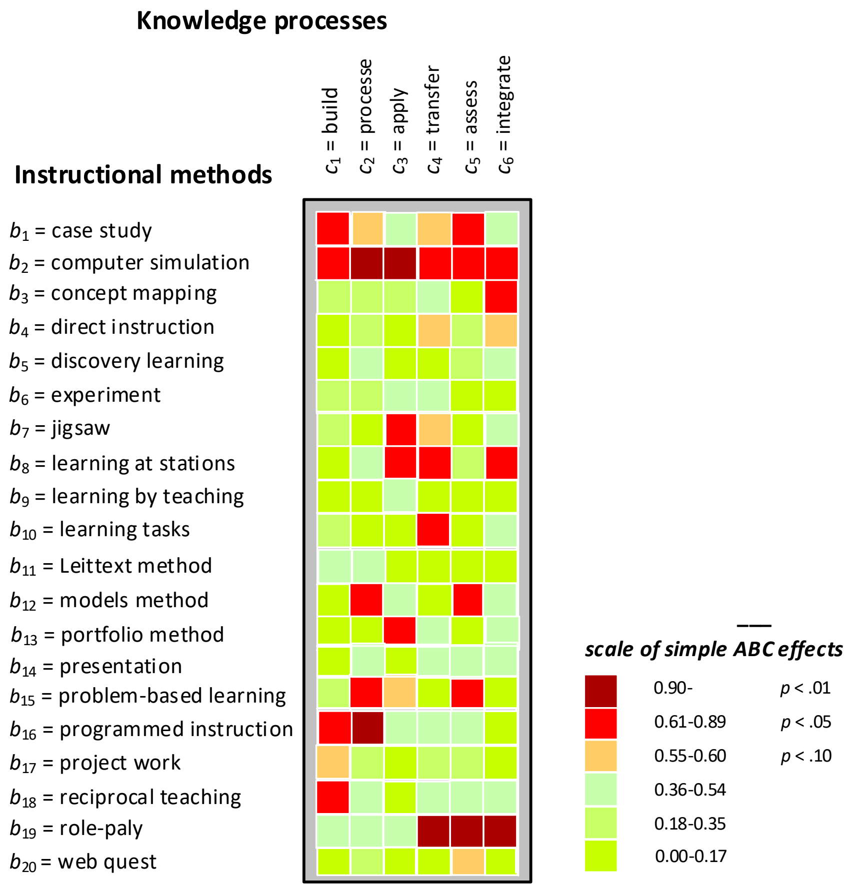

Figure 5. Individual comparisons ($A \bullet B \times C$ interactions)

In sum, our results for the *discover variations goal* show that it is indeed possible to identify combinations of instructional methods and knowledge processes in computer science education context that are also important for the mathematics science education context, as reflected by individual comparisons of the $A \bullet B \times C$ interaction. In particular, significant differences were detected in the two groups' ratings of the relationships of the following instructional methods with respect to *individual* knowledge processes:

- *case study* with respect to *build, assess* (rated higher by computer science teachers);
- computer simulation with respect to build, process, apply, transfer, assess, integrate (rated higher by computer science teachers);
- concept mapping with respect to integrate (rated higher by mathematics teachers);
- jigsaw with respect to apply (rated higher by mathematics teachers);
- learning at stations with respect to apply, transfer, integrate (rated higher by mathematics teachers);
- learning tasks with respect to transfer (rated higher by computer science teachers);
- models method with respect to process, assess (rated higher by computer science teachers);
- portfolio method with respect to apply (rated higher by mathematics teachers);
- problem-based learning with respect to process, assess (rated higher by computer science teachers);
- programmed instruction with respect to build, process (rated higher by computer science teachers);
- reciprocal teaching with respect to build (rated higher by computer science teachers);
- role-play with respect to apply (rated higher by computer science teachers).

Findings for the *Assemble and Integrate Goal*

In order to find answers for the a*ssemble and integrate goal*, the instructional methods are sorted in descending order with respect to the grand means, independently for the computer science teachers and the mathematics teachers (see **Figure 6**). Then instructional methods are highlighted with an asterisk that support at least one

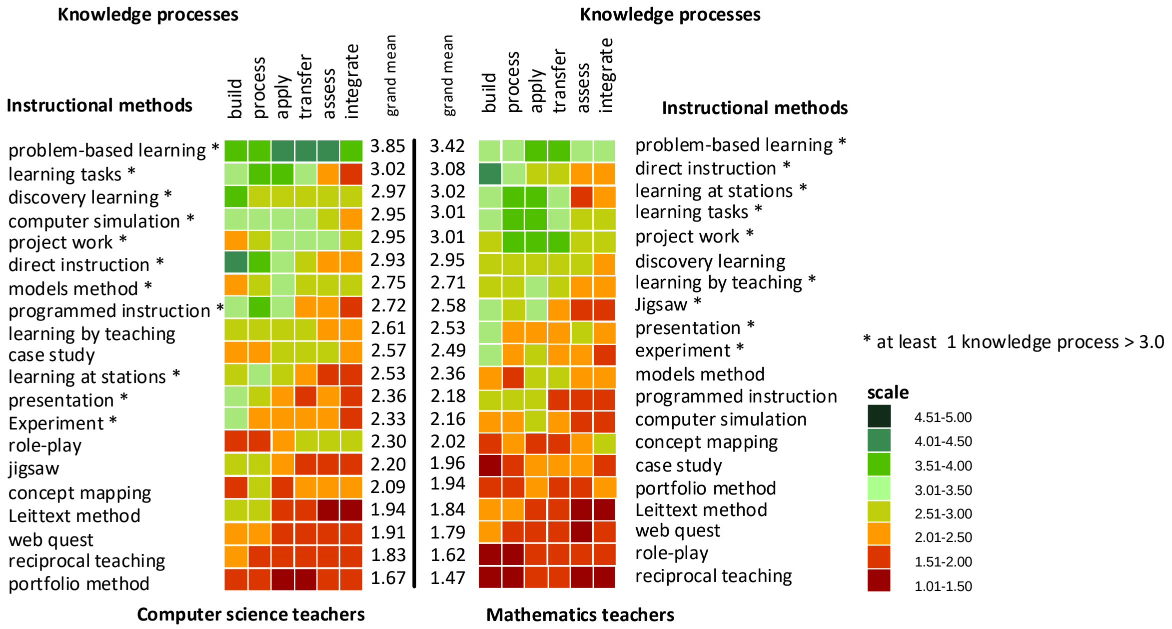

Figure 6. Instructional methods rated by computer science and mathematics teachers (sorted by grand means)

knowledge process very well. The criteria for this is that a knowledge process was rated by the teachers with a value > 3.00.

From the perspective of the computer science teachers, the following eleven methods fulfilled this criterion: problem-based learning, learning tasks, discovery learning, computer simulation, project work, direct instruction, models methods, programmed instruction, learning at stations, presentation, and experiment.

From the perspective of the mathematics teachers, the following nine methods fulfilled this criterion: problem-based learning, direct instruction, learning at stations, learning tasks, project work, learning by teaching, jigsaw, presentation, and experiment.

For the integrative view on instructional methods the criterion that at least one knowledge process was evaluated with a value > 3.00 *both* by computer science *and* by mathematics teachers was used. The following seven instructional methods fulfilled the criterion: problem-based learning, direct instruction, learning at stations, learning tasks, project work, presentation, and experiment.

Figure 7 shows the many similarities in the ratings of instructional methods by computer science and mathematics teachers: problem-based learning is rated highest in terms of almost all knowledge processes, direct instruction is best suited for the knowledge process of *build*, learning tasks are very well suited for the knowledge processes of *process* and *apply*. Project work is appropriate for the knowledge process of *transfer*. With the exception of problem-oriented learning, all instructional methods are more or less inappropriate for knowledge processes of assess and integrate.

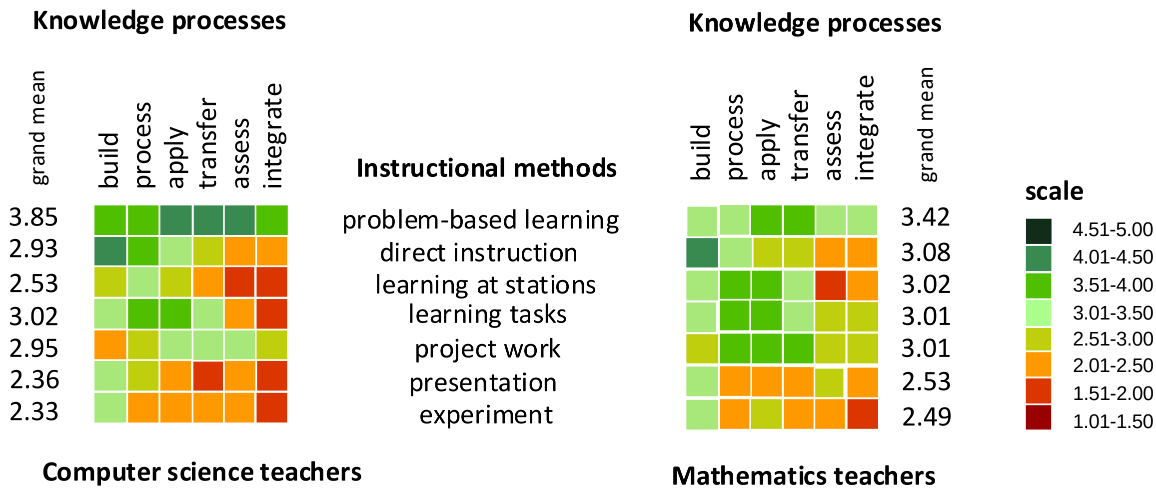

Figure 7. Integrative view on instructional methods

DISCUSSION

It must first be noted that the findings support the research hypothesis formulated in the Introduction that computer science teachers differ from mathematics teachers in their ratings of instructional methods with respect to knowledge processes.

The presented findings on the use of instructional methods in computer science education partly confirm the recommendations made in standard works on the subject of computer science education. This applies to the instructional methods problem-based learning, learning tasks, discovery learning, computer simulation, the project work method and the models method favored in the standard works (Hazzan, Lapidot, & Ragonis, 2011; Iron, Alexander, & Alexander, 2004; Koffmann & Brinda, 2003).

The findings on the application of instructional methods in mathematics education confirm the recommendations made in standard works on the subject of mathematics education. This applies for the instructional methods problem-based learning, learning tasks, learning (at) stations, and project work (Heddens, Speer, & Brahier, 2008; Kidwell & Ackerberg-Hastings, 2008; Li, Silver, & Li, 2014).

The analysis of variance to the *transport and test goal* and the pairwise mean comparisons to the *discover variations goal* showed that computer science and mathematics teachers differ on the ratings of *individual* instructional methods to *individua*l knowledge processes. The greatest differences were found in the rating of computer simulation, case study, programmed instruction, role-play, learning at stations, which the computer science teachers towards the mathematics teachers assessed significantly different. Large differences were also evident in the rating of concept mapping with respect to the knowledge process of *integrate* by mathematics teachers towards computer science teachers. Finally, greater differences were found on the rating of the jigsaw and models method in regard to two knowledge processes.

The results for the *assemble and integrate goal* are very interesting: they allow an integrative view of instructional methods by computer science and mathematics teachers. It was found that both computer science and mathematics teachers top rated problem-oriented learning, and with a lesser degree direct instruction, and project work. The findings support the proposal of the Committee on Integrated STEM Education (2014) to favor these instructional methods, when it comes to the integration of STEM subjects from a teacher's perspective.

The study was conducted with $n_1 = 24$ computer science teachers and $n_2 = 29$ mathematics teachers in the state of Baden-Württemberg who had to make 20 × 6 judgments. The representativeness of the computer science and the mathematics teachers refers to the state of Baden-Württemberg. The results cannot be generalized to other states because of different curricular requirements. Due to the plurality of judgments to be made by the computer science and mathematics teachers maturation effects must be taken into account. For this, the data were analyzed; statistical tests were conducted according to the necessary requirements.

CONCLUSIONS

The results obtained are important for pre- and in-service training programs, especially for countries not yet having a complete teacher training course at university for computer science – as in some states of Germany. The introduction of a new subject in schools represents a particular challenge for teacher training programs. First, the dilemma associated with all new subjects has to be addressed. On the one hand, if teachers are trained before a new subject is introduced, there is a risk that they will not find employment after graduation. On the other hand, a new subject can be successfully introduced only if sufficient numbers of appropriately trained teachers are available. When computer science was first implemented as a compulsory subject in academic-track schools (called Gymnasium) in the southern German state of Bavaria, this dilemma was resolved by providing specific in-service training programs for teachers (called SIGNAL and FLIEG) that qualified to teach computer science as a supplementary subject (Spohrer, 2009). With the obtained result to the *assemble and integrate goal,* educational quality can be achieved when selecting teachers to post-qualify: choosing mathematics teachers, teachers with adequate attitudes on using instructional methods are in focus, even in regard to computer science education.

In follow-up work studies with computer science teachers and teachers, who teach other STEM subjects, should be carried out in order to recruit and post-qualify teachers from a methodological point of view, especially teachers who already possess experiences in instructional methods important to computer science education.

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APPENDIX

A-1 Process Models of Instructional Methods (Three Examples)

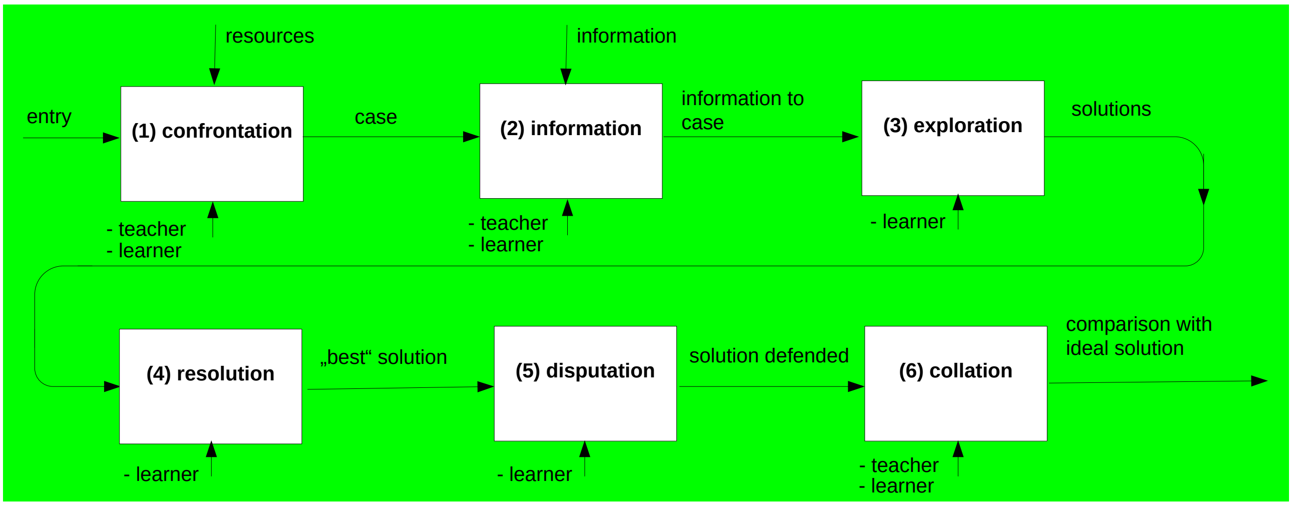

Figure A-1. Case study

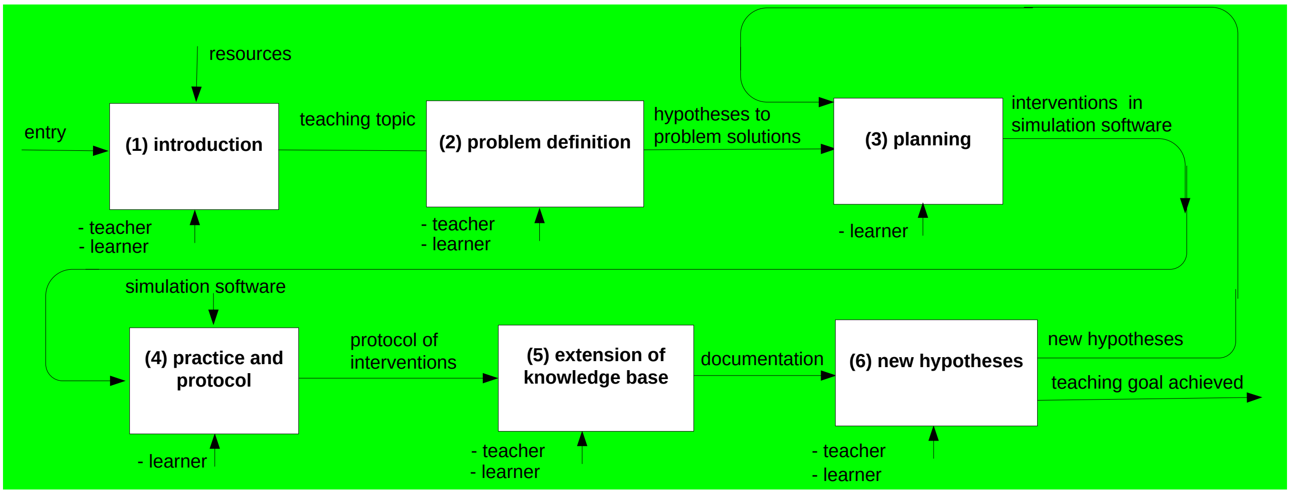

Figure A-2. Computer simulation

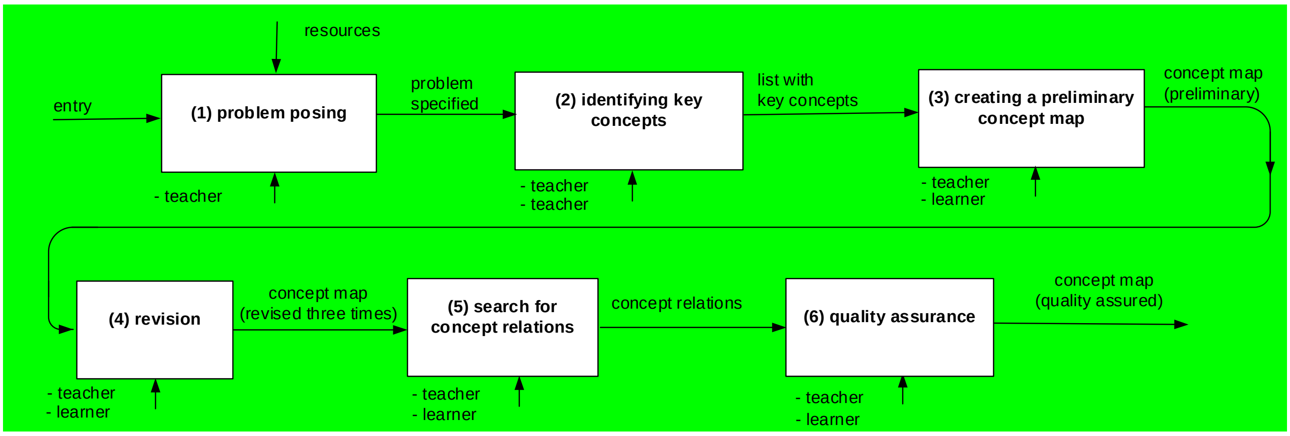

Figure A-3. Concept mapping

APPENDIX

A-2 Questionnaire

Please evaluate:

The act of learning through instructional methods.

Please rate each cell on a scale of 0 to 5 (only whole numbers).

It is important that you provide 6 ratings per row.

	Knowledge processes (Explanations, see Booklet) **Instructional methods** (Explanations, see Booklet)	build	process	apply	transfer	assess	integrate
1	case study						
2	computer simulation						
3	concept mapping						
4	direct Instruction						
5	discovery learning						
6	experiment						
7	jigsaw						
8	learning at stations						
9	learning by teaching						
10	learning tasks						
11	Leittext method						
12	models method						
13	portfolio method						
14	presentation						
15	problem-based learning						
16	programmed instruction						
17	project work						
18	reciprocal teaching						
19	role-play						
20	web quest						

APPENDIX

A-3 Data

a_1 = computer science teachers

Knowledge processes / Instructional methods	c_1 = build	c_2 = process	c_3 = apply	c_4 = transfer	c_5 = assess	c_6 = integrate	*grand means*
b_1 = case study	2.25	2.21	2.83	2.83	2.88	2.42	2.57
b_2 = computer simulation	3.21	3.00	3.13	3.17	2.75	2.38	2.94
b_3 = concept mapping	1.92	2.33	1.71	2.08	2.29	2.21	2.09
b_4 = direct instruction	4.29	3.58	3.08	2.58	2.00	2.08	2.94
b_5 = discovery learning	3.71	2.67	2.83	2.92	2.92	2.92	2.99
b_6 = experiment	3.29	2.13	2.50	2.04	2.08	1.92	2.33
b_7 = jigsaw	2.96	2.92	2.25	1.71	1.79	1.58	2.20
b_8 = learning at stations	2.96	3.17	2.96	2.42	1.88	1.88	2.54
b_9 = learning by teaching	2.75	2.83	2.88	2.67	2.38	2.17	2.61
b_{10} = learning taks	3.00	3.92	3.67	3.38	2.17	1.96	3.01
b_{11} = Leittext method	2.83	2.63	1.92	1.83	1.25	1.25	1.95
b_{12} = models method	2.13	2.67	3.00	2.96	2.92	2.88	2.76
b_{13} = portfolio method	1.71	1.92	1.42	1.38	1.92	1.67	1.67
b_{14} = presentation	3.08	2.83	2.33	1.92	2.00	1.96	2.35
b_{15} = problem-based learning	3.67	3.75	4.21	4.00	4.00	3.54	3.86
b_{16} = programmed instruction	3.42	3.63	3.13	2.42	2.04	1.71	2.72
b_{17} = project work	2.25	2.92	3.33	3.29	3.13	2.75	2.94
b_{18} = reciprocal teaching	2.08	1.96	1.79	1.83	1.79	1.75	1.87
b_{19} = role-play	1.67	1.79	2.29	2.79	2.79	2.58	2.32
b_{20} = web quest	2.33	2.17	1.67	1.79	1.92	1.71	1.93
grand means	2.78	2.75	2.65	2.50	2.34	2.16	***2.53***

a_2 = mathematics teachers

Knowledge processes / Instructional methods	c_1 = build	c_2 = process	c_3 = apply	c_4 = transfer	c_5 = assess	c_6 = integrate	*grand means*
b_1 = case study	1.41	1.62	2.38	2.28	2.17	1.90	1.96
b_2 = computer simulation	2.41	2.03	2.55	2.45	2.00	1.52	2.16
b_3 = concept mapping	1.59	2.07	1.52	1.72	2.41	2.83	2.02
b_4 = direct instruction	4.31	3.52	2.97	2.97	2.21	2.48	3.07
b_5 = discovery learning	3.83	3.00	2.90	2.76	2.66	2.55	2.95
b_6 = experiment	3.48	2.31	2.76	2.38	2.14	1.86	2.49
b_7 = jigsaw	3.24	2.93	3.07	2.31	1.93	2.00	2.58
b_8 = learning at stations	3.07	3.62	3.76	3.21	1.97	2.48	3.02
b_9 = learning by teaching	2.83	2.93	3.38	2.72	2.28	2.14	2.71
b_{10} = learning taks	3.17	3.86	3.66	2.72	2.28	2.38	3.01
b_{11} = Leittext method	2.34	2.24	1.97	1.83	1.38	1.28	1.84
b_{12} = models method	2.03	2.00	2.55	2.86	2.28	2.45	2.36
b_{13} = portfolio method	1.69	1.97	2.14	1.90	1.90	2.07	1.94
b_{14} = presentation	3.14	2.45	2.38	2.28	2.52	2.45	2.53
b_{15} = problem-based learning	3.48	3.03	3.62	3.90	3.17	3.31	3.42
b_{16} = programmed instruction	2.59	2.72	2.59	2.00	1.59	1.59	2.18
b_{17} = project work	2.83	3.10	3.28	3.10	2.97	2.79	3.01
b_{18} = reciprocal teaching	1.38	1.45	1.69	1.66	1.38	1.28	1.47
b_{19} = role-play	1.21	1.31	1.93	1.76	1.86	1.66	1.62
b_{20} = web quest	2.38	1.93	1.79	1.69	1.34	1.62	1.79
grand means	2.62	2.51	2 64	2.42	2.12	2.13	***2.41***

Figure A-4. Mean ratings (n_1=24; n_2=29)

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Effects of the Application of Multimedia to Library Use Education on Learning Motivation and Learning Satisfaction

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ABSTRACT
The use of libraries is considered as the best method to catch up with the time and learn new information in the modern busy society. For an ideal learning society, a library is the most convenient learning center for the public and conforms to the philosophy of self-relearning in lifelong education. It is the most important unit to connect school education and community education as well as the most possible power to implement lifelong education with the combination of the government and the civil. With experimental design model, total 180 students in Shanghai University of Medicine & Health Sciences, as the research object in this study, are proceeded the 15-week (3 hours per week for total 45 hours) experiment applying multimedia to library use education. The research results show significant correlations between 1.library use education and learning motivation, 2.library use education and learning satisfaction, and 3.learning motivation and learning satisfaction. According to the results, suggestions are proposed, expecting to enhance students' library resource use and use frequency to promote learning motivation and learning satisfaction.

Keywords: multimedia, library use education, learning motivation, learning satisfaction

INTRODUCTION

With "holistic education" as the goal, "life education" as the basis, "lifelong education" as the spirit, and "complete learning" as the process, it aims to cultivate good nationals of the society and good citizens of the world to make the nation be more competitive and the people live better. For an ideal learning society, a library is the most convenient learning center for the public and conforms to the philosophy of self-relearning in lifelong education. It is the most important unit to connect school education and community education as well as the most possible power to implement lifelong education with the combination of the government and the civil. Overall speaking, the role of a library in students' self-learning is not obvious. It is the priority for all libraries to match current lifelong education policies and reinforce the promotion of library service and function. A good library is a treasure house of knowledge as well as the source of wisdom. In the modern busy society, the use of library is the best way to catch up with the time and learn new information. Besides, students' reading ability would directly affect the subject learning that reading achievement is an important indicator of reading efficacy at school. The earlier application of correct reading could help the development of brain and language. For this reason, the reading guidance of a library is the focus of library service to guide students' reading interests and ability. School libraries positively utilize the collections for reading promotion to enhance the reading atmosphere on campus.

A library is a non-profit institution aiming to provide service and play the role of supporting teaching, research, promotion, and service. In traditional library environment, the frontline librarians used to be the first impression of readers about the library service quality. Now, in the Internet environment, readers would judge the library service quality by the offered network resources and services. In this case, having students know the environment and facilities of school libraries and guiding them the use method could have students learn to utilize library

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Contribution of this paper to the literature

- Students have to use school library for the reading. However, the collections in school library cannot satisfy most students' needs. In this case, the cross-school and cross-district joint library lending system could be established.
- The function of a school library should be developed the maximum effectiveness. In addition to the positive promotion, it relies on teachers integrating multimedia into teaching activity and course design so that students would really regard school libraries as an important learning channel.
- School teachers with interests in library science should be encouraged to participate in off-campus seminars and trainings to become the seed teachers of the school and design the school-based curricula conforming to the school situation.

resources and present autonomous learning to enhance the learning motivation and learning satisfaction. Multimedia is therefore applied to library use education for understanding the effect on students' learning motivation and learning satisfaction in this study. It is expected to enhance students' library resource use and use frequency to promote the learning motivation and learning satisfaction.

LITERATURE REVIEW

Multimedia Teaching

Chiang, Lin, and Hwu (2013) considered that computers could attract students' attention through vivid images, fresh colors, and texts & sound to further enhance students' learning concentration and interests. For information integrated teaching, it is an important issue to well apply network resources in the network development era. A lot of computer-assisted teaching systems are developed in order to help teachers guide students using network resources. Hsu, Huang, and Hsieh (2014) defined multimedia as texts and pictures. Texts referred to language types, including written visual texts and oral expression texts; pictures, as image types, contained static pictures (illustration, hodograph, diagram, photo, and map) and dynamic pictures (animation and film). Abdi (2013) proposed multimedia learning derivatives, which emphasized that all learning should go through three processes of selection, organization, and integration of pictures and texts. Selection referred to selecting related and important information from text and non-text information and storing in working memory, then the selected text and non-text information were organized and established the structure to form two situational models conforming to the logic, and finally the two organized situational models were integrated and combined. Multimedia learning referred to the utilization of text and picture learning that multimedia learning could be called dual-code learning or dual-channel learning, i.e. multimedia presentation as information being presented with texts and pictures. Multimedia teaching information or multimedia teaching presentation explained learning with texts and pictures (Ihmeideh, 2014; Wu & Tai, 2016; Yi, 2017; Ferreira, Baptista & Arroio, 2013; Alves, Ribeiro, Cunha, Pereira, & Pinto, 2016; Abbasi, Moeini, Shahriari, Ebrahimi, & Khoozani, 2018).

Library Use Education

Clark (2013) indicated that library use education was to teach students knowing school library environment and facilities and guide students of reading methods; meanwhile, it allowed students learning the utilization of library resources to present autonomous learning. It was further explained that library use education contained 1.allowing students knowing library services – printing manuals, making introduction CD, and multimedia interpretation, and leading visits, 2.guiding students to apply library collections – use guidelines and special bibliography guidelines, and holding seminars, and 3.online library use instruction and teaching activity. Al-Awidi and Ismail (2014) explained broad and narrow library use education. The former referred to library use education from elementary school, high school, university to entering the society, aiming at readers' learning for knowledge to develop the research and creation objectives, and further develop to special objectives for different industries. The latter referred to the library use counseling education practiced with formal education at the school learning stage. Issa et al. (2013) indicated that the practice at elementary school, high school, and university stages focused on the use of school libraries, teaching students about the use of library service and the knowledge and skills of collections. Owing to the rapid development of information technology and the changes of students' reading habits, Hsu, Chang, and Hsieh (2015) proposed to rename library use education as "library information use education", aiming to have the content of library use education based on information literacy to teach all teachers and students the skill to utilize printed, non-printed, and electronic resources.

Referring to Hsu et al. (2015), library use education contains the following dimension in this study.

(1) Service dimension: including "knowing library", "understanding library service", and "use equipment & resources".

(2) Information literacy: containing "understanding the value of information", "effective independent information enquiry", "information evaluation", and "organization and use of information".

(3) Lifelong learning: covering "cultivation of computer literacy", "cultivation of media literacy", and "cultivation of network literacy".

Learning Motivation

Grove, Burns, and Gray (2013) proposed that learning motivation was not naturally affected by environment and reinforcers; there were many factors in students' learning motivation, including school, teachers, peers, course materials, and off campus. Parish et al. (2013) further indicated that, in specific situations, students with learning motivation were willing to positively learn, could well apply the resource management strategy to learn time planning, overcome learning difficulty and seek for support, continuously learn, and construct knowledge with learned cognitive strategies to achieve the learning goal. Alickovic and Subasi (2016) regarded learning motivation as individual psychological needs for pursuing success, i.e. learners finding out the meaning and value of learning activity and attempting to pursue the growth. Jhang (2014) proposed that students remained the study and learning activity, and learning could have students automatically engage in maintaining the learning motive. Saelao, Tubsree, and Markwardt (2016) defined learning as the process acquiring knowledge and changing behaviors due to experiences. Conejeros and Mansilla (2014) also indicated that learning motivation could have an individual be more positive on learning in order to maintain learning activity and continue the behavior towards the learning goal. Terrazas-Arellanes, Knox, Strycker, and Walden (2016) stated that learning motivation could induce individual learning activity and maintain the learning activity to have the activity move toward certain learning goal.

Referring to Huang and Chuang (2016), learning motivation includes the dimensions of knowledge interests and external expectation in this study.

(1) Knowledge interests: To maintain and guide the process of study and learning activity, automatically invest the efforts in the learning, and maintain the learning motive.

(2) External expectation: To participate in learning for following the instruction or satisfying the expectation of external others, who were normally authorities, including parents, family members, employers, and even other adult learners.

Learning Satisfaction

Jin, Zhao, Chow, and Pecht (2014) considered that the closer relationship between teachers and students would enhance students' satisfaction with the teachers, and the more course content conforming to students' learning needs and interests could better promote students' learning satisfaction. Yuan, Powell, and CETIS (2013) pointed out the meaning of learning satisfaction as learners' inner feelings and attitudes in the learning process and the degree of learners' desires and needs for learning being satisfied and achieved. Coombs, Curtis, and Crookes (2013) discovered that learning satisfaction referred to learning activity satisfying personal needs as well as learners, in the learning process, being able to perceive learning activity and satisfy personal learning needs to generate good perception and positive attitudes. Qi, Tian, and Shi (2013) also pointed out learning satisfaction as students' feelings and attitudes, during or after learning; when they felt happy or presented positive attitudes, it was satisfaction; on the contrary, they were dissatisfied when feeling unhappy or presenting negative behaviors. Doherty and Thompson (2014) proposed that learners acquiring satisfaction and finding out pleasure in the learning would remain the motivation for continuous learning. In this case, learning satisfaction was an important indicator to measure learning outcome and learner satisfaction with learning as well as the judgment standard to induce learners' motivation for course design or efficacy success.

Course content, teaching methods, and learning methods, proposed by Cheng et al. (2016), are regarded as the dimensions to measure learning satisfaction in this study.

(1) Course content: new knowledge in the course, explanation of contents, rich courses, and diverse courses.

(2) Teaching methods: evaluation of assignment, multimedia teaching methods, teaching interactivity of courses, lively teaching methods.

(3) Learning methods: interface operation, home learning, control of learning time, repeatedly viewing course content.

Research Hypothesis

Hsu et al. (2015) mentioned that the advance of the time changed the idea of a library being simply a book storage building. Particularly, the rapid growth of human knowledge and the increasing accumulation resulted in readers being difficult to thoroughly and effectively utilize the organization, classification, and search method for book information without certain guidance (Clark & Mayer, 2016). Through library use education, readers could realize the importance of information in life and pay attention to the application in life. Meanwhile, cultivating readers' information retrieval ability could reduce librarians' business loads to further use the time for offering better service. Furthermore, the use education process could build the professional image of librarians and enhance the status of a library (Türk & Erçetin, 2014). Lin and Wu (2013) regarded library use education as to teach readers knowing a library and further instruct readers to use various library resources and services to enhance the information search ability, effectively and thoroughly apply various library supports to self-research and learning so as to establish the lifelong learning ability. Al-Awidi and Ismail (2014) stated that a school library could cultivate students' information literacy and establish the lifelong learning basis through library use education. Accordingly, the following hypothesis is proposed in this study.

H1: Library use education shows significant correlations with learning motivation.

Mireku (2016) pointed out three reasons for the practice of library use education. 1. The diverse contents of library use education could educate students to effectively apply distinct information. 2. Knowledge was not passively, but constructed by learners; and, use education was to educate students to self-construct knowledge with information. 3. Education in the new era paid attention to the cultivation of learning attitude and ability; and, use education could have students cultivate the positive and active self-learning habit. Hsiao, Tsai, and Kao (2013) regarded the importance of library use education as the sequence of enhancing students' self-learning ability, cultivating students' library and information use ability, cultivating students' lifelong learning habit, and changing students' learning method and attitude. Niknejad and Rahbar (2015) indicated that the practice of library use education could enhance students' library use frequency, promote the information application ability, and cultivate the lifelong learning habit. After accepting library use education, teachers could apply it to real teaching and deepen and broaden students' learning with rich teaching contents and methods (Alickovic & Subasi, 2016). The following hypothesis is therefore proposed in this study.

H2: Library use education reveals remarkable correlations with learning satisfaction.

Uysal and Gunal (2014) discussed the relationship between learning motivation and learning satisfaction of students in Department of Beauty Science and proved the significantly positive relationship. Morgan (2013) mentioned the positive correlation between learning motivation and learning satisfaction that learning motivation not being satisfied would not appear satisfactory learning results. Cheng et al. (2016) studied the members of Digital Machine Association Center and found out the positive correlation between the learning motivation and learning satisfaction, i.e. members with stronger learning motivation presenting higher learning satisfaction. Ross et al. (2014) discovered that the higher learning motivation would show higher learning satisfaction, and learning motivation presented predictability on learning satisfaction. Research found out the stronger learning motivation, the higher learning satisfaction. Learning satisfaction was not simply the evaluation indicator of learning results, but the major indicator to induce learning motivation and develop curricula. Doherty and Thompson (2014) found out the remarkably positive correlation between learning motivation and learning satisfaction. Sullivan (2015) pointed out notable correlations between students' learning motivation and learning satisfaction that the stronger motivation appeared the higher learning satisfaction. As a result, the following hypothesis is proposed in this study.

H3: Learning motivation presents notable correlations with learning satisfaction.

RESEARCH METHOD

Method and Model

The test for goodness-of-fit with LISREL could be measured from the overall model fit (external quality of model) and internal quality of model. Regarding the overall model fit, the common goodness-of-fit indices contain (1) "$\chi 2$ ratio" (Chi-Square ratio), presenting the gap between actual theoretical model and expected value, which is better smaller than 3, (2) goodness-of-fit index (GFI) and adjusted goodness-of-fit index (AGFI), which reveal the better goodness of fit when being closer to 1, (3) root mean square residual (RMR) of the square root of "fit residual variance/covariance mean", which is better smaller than 0.05, and (4) incremental fit index (IFI), which presents good model fit when being higher than 0.9.

The common evaluation indicators of internal model quality with LISREL include (1) SMC (square multiple correlation) of individual manifest variable, i.e. R2 of manifest variables and latent variables, which should be larger than 0.5, (2) component reliability (ρ) of latent variables, as the Cronbach's α of the observation indicator of latent

Table 1. Model analysis result

	Evaluation indicator	Judgment standard	Result
Overall fit	p -value	p -value > 0.05	0.000
	$\chi 2$/d.f.	< 3	1.283
	GFI	> 0.9	0.976
	AGFI	> 0.9	0.921
	CFI	> 0.9	0.963
	RMR	< 0.05, better lower than 0.025	0.014
	RMSEA	0.05~0.08 good better lower than 0.05	0.043
	NFI	> 0.9	0.933
	IFI	> 0.9	0.906

Table 2. SMC of variable to dimension

Learning motivation	
Knowledge interests	External expectation
0.74	0.78

Table 3. SMC of variable to dimension

Library use education			Learning satisfaction		
Service dimension	Information literacy	Lifelong learning	Course content	Teaching methods	Learning methods
0.72	0.76	0.82	0.75	0.82	0.84

variables, which should be larger than 0.6, and (3) average variance extracted of latent variables, which is calculated by the R2 sum of manifest variables of a latent variable divided by the number of manifest variables, revealing the percentage of latent variables being measured through manifest variables, which is better larger than 0.5.

Research Sample and Object

With experimental design model, total 180 students in Shanghai University of Medicine & Health Sciences, as the research object, are proceeded the 15-week (3 hours per week for total 45 hours) experimental teaching with the application of multimedia to library use education.

Reliability and Validity Test

Validity refers to a measuring scale being able to actually measure the degree of what a researcher would like to measure. Common validity contains "content validity", which tends to qualitative test, "criterion validity", which is evaluated with set external criterion and the correlation coefficient in the test, and "construct validity", which is used for evaluating the consistency of the measurement with other observable variables. The questionnaire content in this study is based on past theories and refers to the actual conditions of the research object to ensure the content validity. The final commonality estimate of the Factor Analysis result is applied to test the construct validity of dimensions and the acquired validity appears in 0.7~0.9 that the research questionnaire presents favorable validity.

ANALYSIS OF EMPIRICAL RESULT

Model Fit Test

The estimation with "Maximum Likelihood" (ML) is utilized in this study, and the analysis result achieves convergence. Overall speaking, the indicators of overall model fit pass the test, **Table 1**, thoroughly reflecting the favorable external quality of the model.

Test of Path Relationship

In terms of internal model quality test, SMC of manifest variables is higher than 0.5 (**Table 2** & **3**), revealing good measurement indicators of latent variables. Furthermore, latent variables of learning motivation, library use education, and learning satisfaction show the component reliability higher than 0.6, and the average variance extracted of dimensions is higher than 0.5 (**Table 4**), conforming to the requirement for internal model quality.

Table 4. Component reliability of variable and average variance extracted

Item	Learning motivation	Library use education	Learning satisfaction
Component reliability	**0.833**	**0.857**	**0.869**
Average variance extracted	0.81	0.83	0.84

Table 5. Linear Structural Relations Model analysis

Evaluation item	Parameter/Evaluation standard	Result	t
internal goodness of fit	library use education→learning motivation	0.851	27.41**
	library use education→learning satisfaction	0.884	34.25**
	learning motivation→learning satisfaction	0.863	29.66**

Table 6. Hypothesis test

Research hypothesis	Correlation	Empirical result	p	Result
H1	+	0.851	0.00	supported
H2	+	0.884	0.00	supported
H3	+	0.863	0.00	supported

Table 5 reveals positive and significant correlations between library use education and learning motivation (0.851), library use education and learning satisfaction (0.884), as well as learning motivation and learning satisfaction (0.863), that H1, H2, and H3 are supported. The test of research hypotheses in this study is shown in **Table 6**.

CONCLUSION

The research results reveal that "covering reading interests, habits, and methods" is the priority of the curriculum goal of school library use education, the course content focuses on "knowing library environment, function, and basic service", and it should be practiced by matching school reading promotion activity. Current library equipment should stress on network resources, as traditional paper-based books would be replaced by online reading. Besides, students generally search for data with computer networks, rather than traditional textbooks and knowledge in book. In this case, school library use education in the network era should instruct students of basic use and teach them how to use new information media. The application of network resources is especially important that online service of library should be equipped for students' use, and multimedia can be applied to library use education to promote reading. Library use education of teachers could benefit the teaching effectiveness, as teachers could select proper teaching strategies and resources, e.g. books, magazines, diagrams, and video & audio media, as the assisted materials to guide students' learning to actively search, evaluate, organize, store, explain, communicate, and use information to enhance the learning depth and width.

RECOMMENDATIONS

By organizing the results and findings, practical suggestions are proposed as below.

1. Students have to use school library for the reading. However, the collections in school library cannot satisfy most students' needs. In this case, the cross-school and cross-district joint library lending system could be established. Meanwhile, school libraries could be open on holidays for students' use so as to enhance students' learning motivation and the overall learning atmosphere.
2. The function of a school library should be developed the maximum effectiveness. In addition to the positive promotion, it relies on teachers integrating multimedia into teaching activity and course design so that students would really regard school libraries as an important learning channel. Besides, students should be guided to use library resources at free time and a school library should increase relevant computer network hardware and network related resources conforming to student needs in order to attract the use of students and promote the learning satisfaction.
3. A school indeed would hold several professional trainings for teachers; however, not many teachers would participate, and those trainings even become not deeply discussing how to effectively practice library use education. In this case, school teachers with interests in library science should be encouraged to participate in off-campus seminars and trainings to become the seed teachers of the school and design the school-based curricula conforming to the school situation.

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Mapping the Factors Influencing Success of Massive Open Online Courses (MOOC) in Higher Education

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ABSTRACT
Massive Open Online Courses (MOOC) is a new phenomenon in online learning that has aroused increasing interest by researchers as a significant contribution to improving educational system quality and openness. The purpose of this paper is to compile and analyze MOOC research that has been published between 2012 and 2016. A systematic analysis technique was employed and Template Analysis (TA) approach was used for mapping MOOC research into three dimensions in accordance with the Biggs 3P model. First dimension is *Presage*, include the following factors: Learners' characteristics with sub-factors (learner demographics, learner motivation, and interactivity) and instructor. Second, *Process*, including factors of pedagogy, pattern of engagement, instructional design, assessment, credit, plagiarism, sustainability, and learning analytics. Third dimension is *Product*, including factors of student dropout rate and MOOC quality. This classification is aimed at providing a comprehensive overview for readers interested in MOOCs who seek to understand the critical success factors influencing MOOC success.

Keywords: MOOC, Massive Open Online Courses, MOOC success, MOOC quality

INTRODUCTION

Massive Open Online Courses (MOOC) is a new online learning style with significant capability to expand free online courses to a large number of participants worldwide. MOOC provides opportunities with no admission requirements to open up learning and to offer a wide range of choices in different areas and disciplines for a massive number of participants (Liyanagunawardena, Adams, & Williams, 2013).

Since 2012, MOOC has received increased attention for its significant influence on lifelong learning as confirmed in the consequential Innovation Reports from the Open University, UK (Sharples et al., 2013, 2014). There is growing interest in MOOC by lifelong learners, higher education institutions, and for-profit platforms (Raffaghelli, Cucchiara, & Persico, 2015) as manifested in Google trends for MOOC. **Figure 1** displays a quick glance of Google Trends when searching for MOOC-related keywords.

A Scopus database was employed to explore the most-used terms as keywords in analysis related to MOOC-related publications, as shown in **Figure 2**.

The result from searching the Scopus database revealed 491 publications in which 161 different keywords were used, with the most-used term being "MOOC", used in 113 publications, "Open Course" was used in 108, "Higher Education" in 96, "Massive Open Online Courses" in 59 and "Completion" in 32 publications.

Despite the fact that hundreds of thousands of people around the world are signing up for MOOC systems (Rivard, 2013) only few students complete courses and receive a certificate of completion. Some researchers estimated that the average completion rate of MOOC is below 10% (Alraimi, Zo, & Ciganek, 2015; Hew & Cheung, 2014) while others suggest an even lower than 7% (Parr, 2013).

The main reasons for this high dropout rate may be associated with issues of MOOC systems related to courses, services, and education quality factors such as pedagogies, purposes, roles of instructors, learner motivations,

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Contribution of this paper to the literature

- This study investigates and analyzes the key factors that impact success of MOOC system.
- This paper develops a map of classification that integrates critical factors influencing MOOC system success.
- This study reveals 12 main factors related to successful implementation of MOOC (e.g. learner characteristic, instructor).

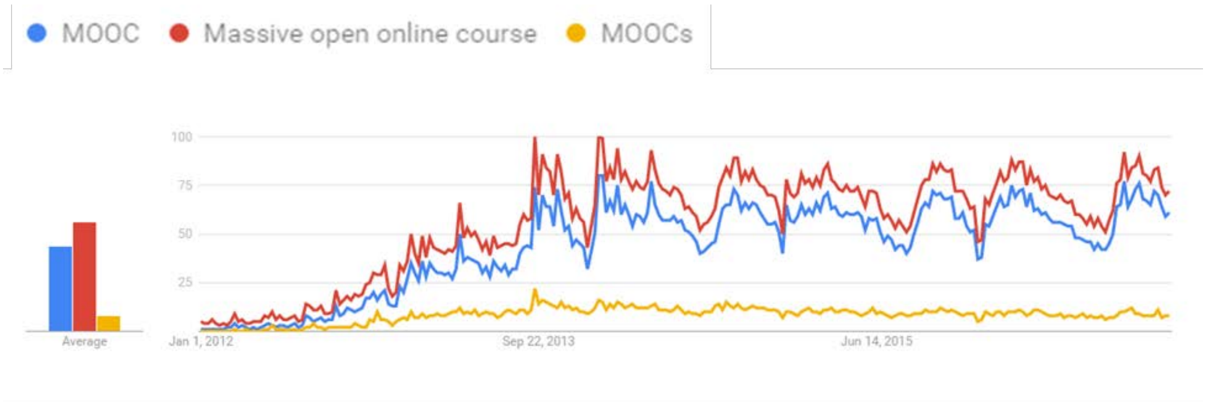

Figure 1. Google Trends for MOOC related keywords

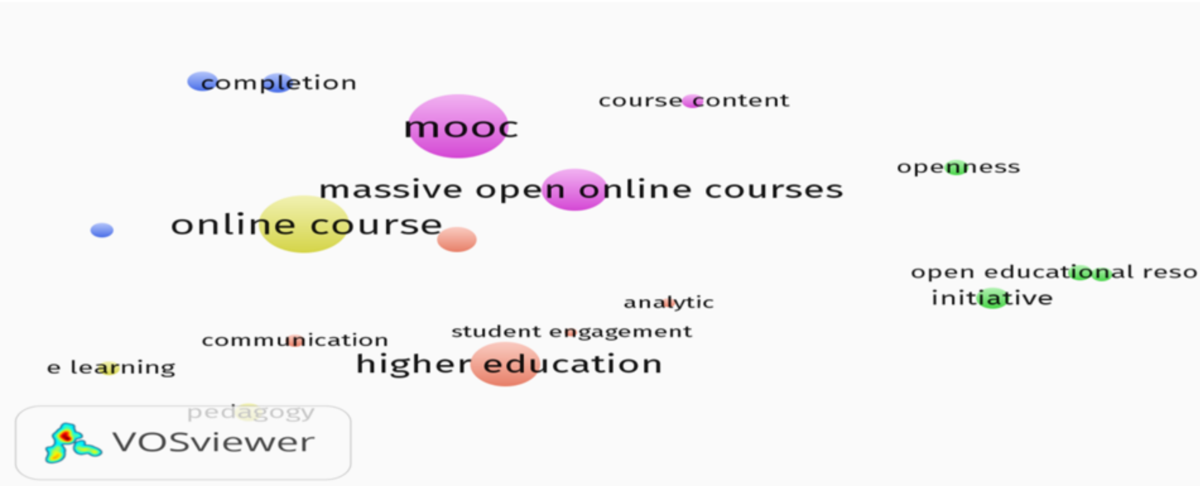

Figure 2. The most term used keyword in Scopus

expectations and behaviors (Milligan, Littlejohn, & Margaryan, 2013) so measuring factors influencing MOOC should be considered a key issue in understanding MOOC success of lack thereof.

While there are widely available studies with empirical evidence that investigate factors influencing success of e-learning (e.g. Yusop, 2015; Yusop & Siti Mariam, 2017), those factors may not be suitable for MOOC because of its the unique features (Gamage, Fernando, & Perera, 2015). Therefore, research on the particular critical success factors of MOOC and dealing explicitly with MOOC participants would seem to be required (Yousef, Chatti, Schroeder, & Wosnitza, 2014c). Most importantly, there is a critical need to examining the success factors of MOOC from a systemic point of view is virtually non-existent except for a study by Gamage et al. (2015). The current study has tried to fill in the current gap in literature by reporting results of a systematic literature review to explore the critical factors influencing success of MOOC systems. Identification of these factors will inform academics and higher education administrators in making informed decisions when adopting MOOC for their institutions and consequently reducing the percentage of failure in MOOC systems.

LITERATURE REVIEW

MOOC is recent phenomena in higher education, and its development is still in infancy, although the body of related research has been progressively growing. There are few systematic scholarly publications related to MOOC. These researches focused on providing descriptive analyses of MOOC literature such as its geographical distribution, publication outlets, citations (e.g. Liyanagunawardena et al., 2013; Veletsianos & Shepherdson, 2016), and analyses of data collection and analysis methods used in researching MOOC (e.g. Bozkurt, Keskin, & de Waard,2016; Veletsianos & Shepherdson, 2016). Additionally, other previous researchers have been focusing on students' use of MOOC, mainly focusing on their motivations and challenges (e.g. Hew & Cheung, 2014; Khalil & Ebner, 2014). Others investigated characteristics related to MOOC (e.g. Liyanagunawardena et al., 2013).

While the above-mentioned articles seem to suggest that research topics on MOOC are diverse (Liyanagunawardena et al., 2013; Raffaghelli et al., 2015) and that the research interest about this topic is continually growing (Veletsianos & Shepherdson, 2016) very little research has been done to understand critical factors influencing the success of MOOC. In view of this, there is a need for a review of relevant MOOC literature to gain a better understanding of the phenomenon.

SIGNIFICANCE OF THE STUDY

The current study represents the first effort to review the MOOC literature that has been published between 2012 and 2016 to understand the critical success factors influencing MOOC success and fills the gap in the literature in this domain. This study adds to the existing MOOC research by investigating in-depth the factors influencing MOOC success to promote successful implementation of MOOC systems within high education contexts.

By applying systematic review techniques, this study intends to contribute to a better understanding of MOOC literature by a mapping of publications related to factors influencing MOOC success based on Biggs's 3P framework to guide researchers, practitioners, institutions, international agencies, associations, and other networks (Anderson & Zawacki-Richter, 2014).

AIM OF THE STUDY

Even though prior studies have emphasized the importance of MOOC success, there remains a lack of clarity about how MOOC could be successfully and effectively implemented. Moreover, little systematic empirical research has been directed towards thorough investigating and analyzing key factors that impact MOOC success (Gamage et al., 2015), so the primary aim of this study is to investigate factors influencing the success of MOOC.

The specific purpose of this paper is to analyze publications related to MOOC research that has been conducted during the period 2012–2016. A Template Analysis (TA) approach was used to map the conducted research on MOOC with the aim of providing an inclusive overview for readers interested in MOOC to increase their common understanding of critical success factors in this emerging field. This paper also aim to offer researchers interested in the subject a systematic view of the main publications and sources of scientific information related to MOOC.

Within this perspective, the research objectives for this study are as follows:

- To critically analyze the literature on MOOC.
- To identify critical factors influencing the success of MOOC.
- To develop a map of classification that integrates critical MOOC factors.

This study has been guided by the following research questions:

- What is the most active research published between 2012 and 2016 that has explored critical factors influencing MOOC success?
- What are the critical factors that influence the success of MOOC?
- How can critical MOOC factors be integrated into map classification?

METHODS

This study employed a systematic reviewing protocol to analyze and synthesize MOOC literature, followed by use of a template analysis approach (King, 2012) to map the conducted research on MOOC. Template Analysis is a technique used to thematically organize and analyze qualitative data. It has been applied extensively in social science researches (King, 2012).

Such systematic reviews are intended to provide guidance to researchers planning future studies, and provide convenient summaries of the literature on a particular issue (Petticrew & Roberts, 2008).

In this systematic review, the literature search was based on the following procedures:

- First, the search terms chosen for recognition, based on Scopus analysis, included "MOOC", "MOOCs", "Massive Open Online Course", "Massive Open Online Courses" "MOOC Success", and "MOOC Quality".

- Second, the search terms were used to search major refereed academic databases such as Web of science, Scopus, ERIC, Open Access Journals Search Engine (OAJSE), and Google Scholar. The current study focuses on these particular databases based on their multidisciplinary nature because they export data for bibliographic searching and literature research results in a standardized format.
- Third, select articles published from 2012-2016, a time frame chosen because MOOC studies in earlier years (before 2012) relied heavily on theoretical research (Hew & Cheung, 2014) and generally reflected small sample sizes (Raffaghelli et al., 2015).
- Fourth, apply the following set of selection criteria for articles to be included in the review:
  - The paper should be written in English and published in the period 2012-2016.
  - Since, the primary focus of this review is on factors influencing MOOC success, learners' perceptions toward using MOOC, learners' characteristics, motivations, attitudes, engagement, satisfaction, and MOOC quality, these factors were included.
  - Articles investigating stakeholders such as students and instructors were included, while papers examining other stakeholders such as employers, software engineers, and librarians were excluded.
  - Articles not meeting the selection criteria, e.g., studies exploring political and policymakers' views or studies expressing personal opinions were excluded.
- Fifth, articles relevant to the topic of MOOC success and meeting the preceding criteria were selected based on information provided in their abstracts, followed by reviewing the full text of each article to eliminate articles not clearly related to MOOC systems success.
- Sixth, a secondary literature research was conducted by reviewing the references of each primary source to explore critical factors influencing success of MOOC.

Then, Template Analysis was used as the classification technique for mapping MOOC literature in several dimensions (King, 2012). Thematic analysis is perfectly appropriate to get a clear picture of the basic content of text. Thematic analysis is believed to be one of the most common methods to content analysis, where the coding scheme is based on categories designed to capture the dominant themes existing in the text (Attride-Stirling, 2001; Bryman & Hardy, 2009). Therefore, the template analysis has been chosen purposefully as a document analysis process to foster the recurrent themes found in published articles on factors influencing success of MOOC in higher education. The template analysis has been done manually using printout tables based on four phases:

Phase one: reading the MOOC literature carefully to identify the studies that are familiar with the domain context.

Phase two: formulating codes (themes) based on understanding the studies domain and using existing MOOC classifications by Yousef, Chatti, Schroeder, and Wosnitza (2014b) and Hood and Littlejohn (2016) as a reference to test reliability. Yousef et al. (2014b) used templet analysis to map the research on MOOC into seven dimensions, namely concept, design, learning theories, case studies, business model, targets groups, and assessment. Hood and Littlejohn (2016) identified a range of variables that can be used to measure quality in MOOC using Biggs's (1993) 3P model.

Phase three: Categorizing and calculating the frequency of the critical MOOC factors influencing MOOC success according to Biggs's (1993) 3P model, three templates were identify as follows:

1. **Presage** that represents the input variables that related to teaching and learning process such as the learner characteristics and instructors.
2. **Process** which refers to the environment related with the presage variables (e.g. instructional design, and pedagogical approaches).
3. **Product** that represents the outputs of the educational outcomes such as completion rate.

Phase four: conducting several internal meetings to discuss combining and contrasting the findings from several studies into themes or coding in the textual data (e.g. Instructor, instructional design) then organized them in the templates (e.g. presage, process). **Table 1** displays the classification of the studies included in this review according to the templates and themes.

Table 1. Classification of selected MOOC papers based on Biggs's (1993) 3P model

Template	Factor	Studies
Presage	Learner demographics	(Christensen et al., 2013; DeBoer et al., 2014; Ho et al., 2014; Liyanagunawardena, et al., 2015; Morris, 2014; Morris, Hotchkiss, & Swinnerton, 2015).
	Learner motivation	(Abeer & Miri, 2014; Belanger & Thornton, 2013; Davis et al., 2014; Hew & Cheung, 2014; Morris & Lambe, 2014; Wen, Yang, & Rose, 2014b; Zheng, Rosson, Shih, & Carroll, 2015).
	interactivity	(Conole, 2013; Grünewald et al., 2013; Guo, Kim, & Rubin, 2014; Kolås, Nordseth& Hoem, 2016; Li et al., 2014; Mamgain et al., 2014).
	Instructor	(Adamopoulos, 2013; Evans & Myrick, 2015; Ferguson & Whitelock, 2014; Haavind & Sistek-Chandler, 2015; Najafi, Rolheiser, Harrison, & Håklev, 2015; Rodriguez, 2012; Ross et al., 2014).
Process	Pedagogy	(Ahn, Weng, & Butler, 2013; Bayne & Ross, 2014; Ferguson et al., 2015; Glance, Forsey & Riley, 2013; Istrate & Kestens, 2015; Toven-Lindsey, Rhoads, & Lozano, 2015; Yuan & Powell, 2013).
	Pattern of engagement	(Anderson, Huttenlocher, Kleinberg, & Leskovec, 2014; Ferguson & Clow, 2015; Hew, 2014; Hill, 2013; Kizilcec, Piech, & Schneider, 2013; Milligan, Littlejohn, & Margaryan, 2013; Nelson, 2014; Phan, McNeil, & Robin, 2016; Veletsianos et al., 2015; Waite, Mackness, Roberts, & Lovegrove, 2013).
	Instructional design	(Amo, 2013; Chen, 2014; Downes, 2013; Lin et al., 2015; Littlejohn et al., 2016; Munoz-Merino et al, 2015; Young, 2013).
	Assessment	(Admiraal, Huisman, & Pilli, 2015; Admiraal, Huisman, & Ven, van de, 2014; Clarà & Barberà, 2014; Kulkarni et al., 2013; Piech et al., 2013; Raposo-Rivas, Martinez-Figueira, & Campos, 2015; Reilly, Stafford, Williams, & Corliss, 2014; del Mar Sánchez-Vera & Prendes-Espinosa, 2015; Sandeen, 2013a; Yousef et al., 2015e).
	Credit	(Billington & Fronmueller , 2013; Bruff et al., 2013; El-Hmoudova, 2014; Green, 2013; Hollands & Tirthali, 2014; Jiang et al, 2014; Kursun, 2016; Sandeen, 2013b; Schulze , 2014; Shen & Kuo, 2015).
	plagiarism	(Eisenberg, 2013; Maas et al, 2014; Marshall, 2014; Meyer & Zhu, 2013; North, Richardson & North, 2014).
	Learning analytics	(Chandrasekaran, Ragupathi, Kan, & Tan, 2015; Daradoumis, Bassi, Xhafa, & Caballe, 2013; Kay, Reimann, Diebold, & Kummerfeld, 2013; Lackner, Ebner, & Khalil, 2015; Tabba & Medouri, 2013).
	Sustainability	(Aparicio, Bacao, & Oliveira, 2014; Burd et al., 2014; Dellarocas & van Alstyne, 2013; Kalman, 2014; Parr, 2013).
Product	Student dropout	(Alraimi et al., 2015; Clow, 2013; Engle, Mankoff, & Carbrey, 2015; Fischer, 2014; Freitas, Morgan, & Gibson, 2015; Greene, Oswald, & Pomerantz, 2015; Hone & El Said, 2016; Jordan, 2014; Khalil & Ebner, 2014; Mackness, Waite, Roberts, & Lovegrove, 2013; Reich, 2014).
	MOOC quality	(Butcher et al, 2013; Gamage, Fernando, & Perera, 2015; Hood & Littlejohn, 2016; Jansen et al, 2016; Margaryan, Bianco, & Littlejohn, 2015; Yousef et al., 2014c).

RESULTS

In this section, we will present the results obtained from analysis and synthesis of information from the set of selected publications, using the procedures described above.

After eliminating unsuitable articles from both the initial and secondary literature searches, the final result of the systematic review study included a set of 102 publications matching the criteria. A PRISMA process was employed for the search, and **Figure 3** displays the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow diagram of critical success factors influencing MOOC.

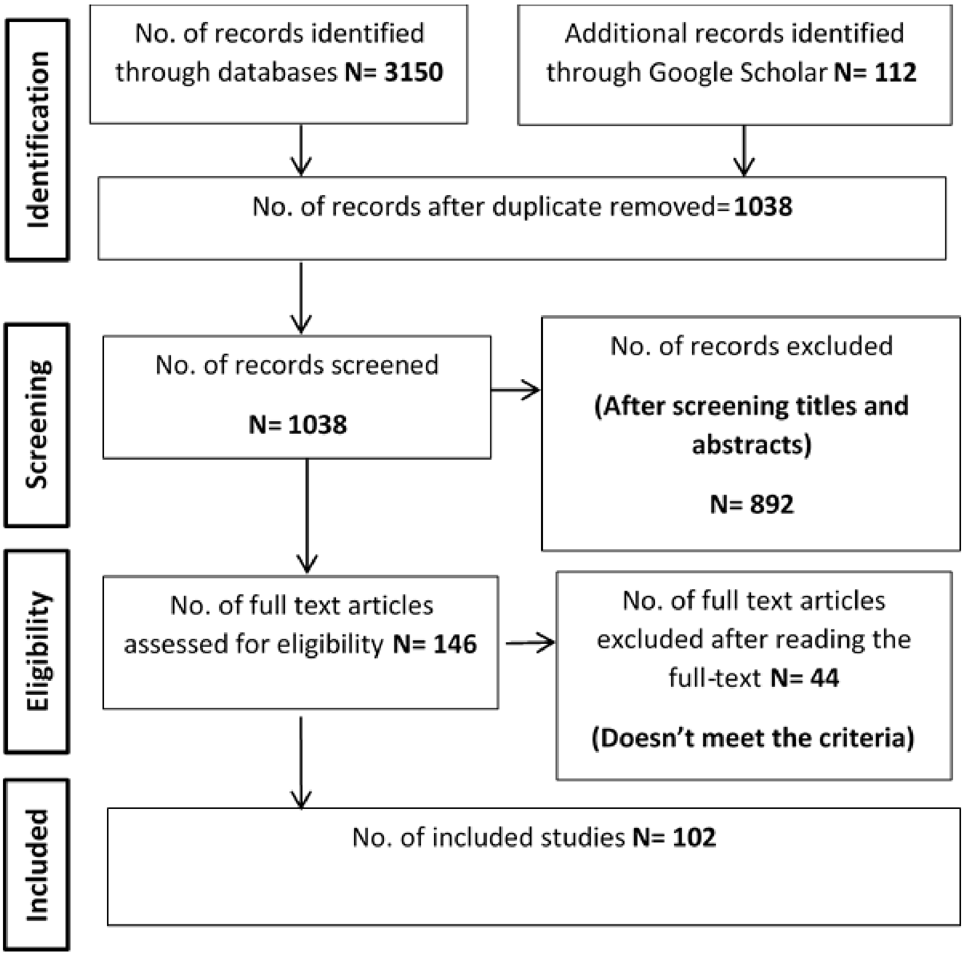

Figure 3. The PRISMA flow diagram of critical success factors influencing MOOC Source: Moher, Liberati, Tetzlaff, Altman, The PRISMA Group (2009)

Table 2. MOOC papers by publication year

	2012	2013	2014	2015	2016
No. of publication	1	32	37	25	7

102 studies were included in the data analysis, and each article identified was the basic unit of analysis. This analysis was conducted from year 2012 to 2016, and the collection of MOOC papers sorted by publication year is shown in **Table 2**.

From the 102 studies, 54 journal articles, 30 conference papers, 12 articles from Web magazines, 5 books, and 1 dissertation were considered as relevant and thus, included for further analyses as displayed in **Figure 4**.

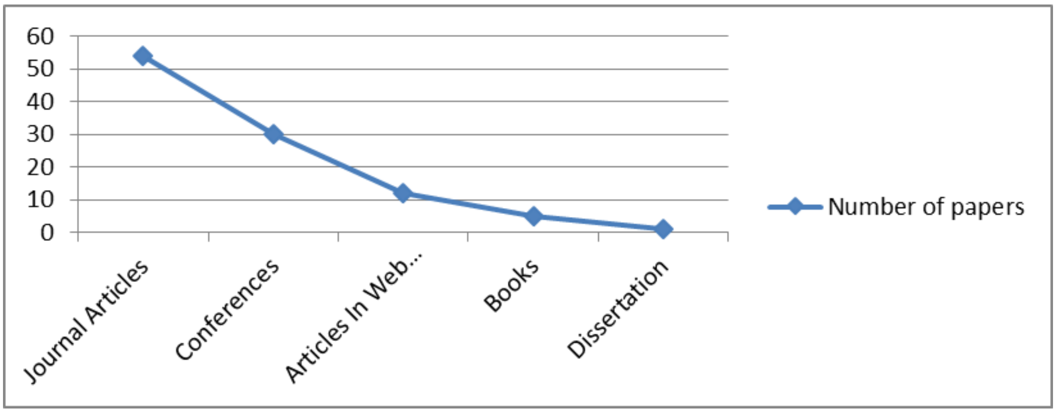

Figure 4. Distribution of articles by type of papers

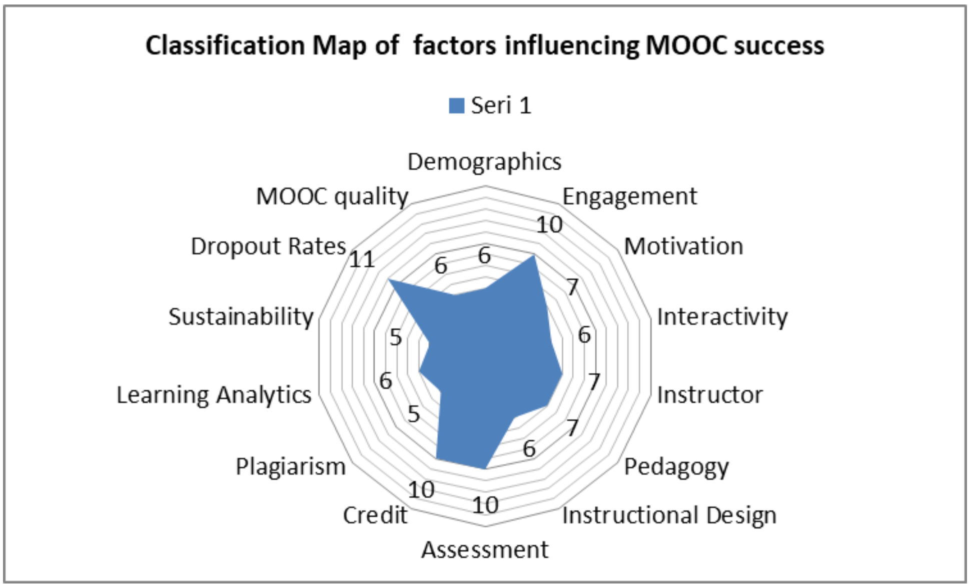

Figure 5. Classification map of factors influencing MOOC success

From this analysis, it can be observed that *The International Review of Research in Open and Distributed Learning*, *Distance Education*, *Computers & Education*, *British Journal of Educational Technology*, *and Journal of Online Learning and Teaching*, were the top 5 journals publishing the greatest number of articles related to MOOC success.

All of the 102 publications that were selected in this review were then mapped into fourteen identified factors that influence the success of MOOC as displayed in the classification map of factors (**Figure 5**). For example, there were 11 studies that suggested dropout rates as the success factor, followed by engagement, credit and assessment (10 studies each); motivation, instructor, pedagogy (7 studies each); demographics, interactivity, instructional design, learning analytics and MOOC quality (6 studies each); and finally, plagiarism and sustainability (5 studies each).

DISCUSSION

After identifying critical factors influencing success of MOOC, Biggs's (1993) 3Pmodel was employed to determine the core components of a MOOC environment. The Biggs model suggests that to understand a particular ecosystem (Biggs, 1993) (e.g., MOOC), it is necessary to break it down into its components and examine how these components relate to one another and how they combine to form the system as a whole. The model divides each learning ecosystem into three types of variables: presage, process, and product. Presage represents input variables related to teaching and learning processes, including learners, motivation, demographics, and instructors. Process variables refer to the environment of the presage variables, including instructional design, and pedagogical approaches. Product variables are the outputs of the educational processes, e.g., outcomes such as completion rate. The Biggs's 3P model is displayed in **Figure 6**.

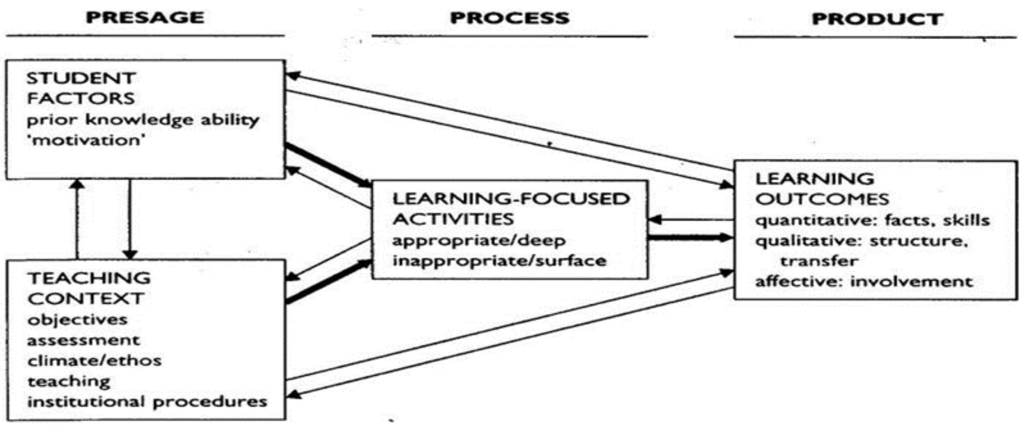

Figure 6. Biggs's 3P model

Presage Variables

The presage variables represent resources and factors related to teaching and learning processes. In the current study there are two (2) presage factors and three (3) sub-factors identified from the systematic literature review. They are:

Learner characteristics

Learner participation is one of the most-examined factors and debates in the MOOC literature. The literature reviewed revealed three sub-factors for learner characteristics: learner demographics, learner motivation, and interactivity.

Learner demographics

While a host of studies have investigated learner demographics, the current literature exploring MOOC currently are not attracting the diversity of learners originally expected. MOOC demographics show that most MOOC learners are already employed, are well-educated, are from developed countries and have been involved in higher education (DeBoer, Ho, Stump, & Breslow, 2014; Liyanagunawardena, Lundqvist, & Williams, 2015).

Christensen et al. (2013) conducted a study published by the University of Pennsylvania in November of 2013 that surveyed nearly 35,000 students from 200 countries who participated in 32 Coursera MOOC. Examining the demographic backgrounds of these MOOC learners revealed that (83%) of participants had a post-secondary degree and (79.4%) had a bachelor's degree or higher. (40%) were under the age of 30, while fewer than (10%) were over 60. There were significantly more males (56.9%) than females, and (62.4%) were employed full-time or self-employed, with only (13.4%) unemployed or retired.

Learner motivation

Motivation plays a vital role in student determination to enroll and continuously participate in MOOC. Wen, Yang, and Rose (2014b) confirmed that, the greater the learner motivation, the lower the risk of dropout.

Learners are motivated to join MOOC for different purposes. Common factors include: interest in the topic, access to free learning opportunities, a desire for refreshing knowledge, an opportunity to draw on world-class university knowledge, and gaining accreditation (Davis et al., 2014).

Hew and Cheung (2014) reported four reasons for why learners sign up for MOOC: a) interest in new technology, b) extending current knowledge, c) collecting as many completion certificates as possible, and d) learning as a personal challenge.

Interactivity

Interaction is the key to participant MOOC success (Khalil & Ebner, 2014), and many researchers pointed out its importance in MOOC environments. Conole (2013) indicated that understanding how learners interact with MOOC should be considered. Kolås, Nordseth and Hoem (2016) pointed out that interactivity in MOOC motivates learning through enhancement of student engagement in a topic.

Instructor

Instructors' motivation for MOOC instruction, their experience in teaching and developing MOOC, and their satisfaction in teaching MOOC have been investigated in many studies (Evans & Myrick, 2015; Najafi, Rolheiser, Harrison & Håklev, 2015). Ross, Sinclair, Knox, and Macleod (2014) argued for the importance of acknowledging the complexity of teacher roles and experiences in MOOC, and how they influence learner engagement.

Further research suggests that instructor participation in discussion forum activities during the execution of a MOOC activity can actively support learners and positively influence learning outcomes. Guo, Kim, and Rubin (2014) found that short videos, inclusion of instructor talking-head videos, and presence of drawing-hand style instructions were the most commonly useful factors for enhancement of student engagement in MOOC. Abeer and Miri (2014) found that student participation in MOOC can be affected by instructor-provided features, including clarity of explanations, visualization of abstract concepts, support and communication, and assignment variety.

Process Variables

Process variables refer to processes and actions related to the presage variables, and in this study eight (8) process variables were identified. They are:

Pedagogy

A host of studies (e.g., Toven-Lindsey, Rhoads, & Lozano, 2015) have investigated MOOC pedagogy. The literature highlights that design MOOC should be clear, consistent, and coherent, and representing a well-defined pedagogical approach (Istrate & Kestens, 2015).

MOOC has evolved into two different pedagogical styles: cMOOC and xMOOC. Broad attempts have been made to distinguish between these styles based on how teaching and learning takes place under their influence. cMOOC are classified with respect to their social mode of learning, while xMOOC are institutionally focused and dependent on video-lecture contents and automated assessment (Bayne & Ross, 2014). cMOOC focuses on connection and collaborative learning while xMOOC emphasizes the extension of existing pedagogical models (Yuan & Powell, 2013).

Because of the contrast between cMOOC and xMOOC, the recent literature has begun to move away from separately considering these basic two styles of MOOC and more toward mediating the contrasts between them (Grunewald, Meinel, Totschnig, & Willems, 2013).

Pattern of engagement

Student engagement in MOOC has achieved a significant interest in the literature (e.g. Phan, McNeil & Robin, 2016). Many studies define engagement in terms of interaction of the learners with instructional materials such as lectures, manuscripts, and assessments, with the data obtained analyzed by different methods to determine trends and patterns in engagement with materials (e.g. Veletsianos, Collier, & Schneider, 2015).

The literature has reported that the complexity and diversity of MOOC participants' perspectives and learner patterns are considered to be one main reason of a high MOOC dropout rate (Waite, Mackness, Roberts, & Lovegrove, 2013), so an understanding of the different patterns of MOOC participants and their perspectives when participating in MOOC appears to be needed.

Hew (2014) studied the features of 965 course participants across three disciplines that have encouraged student engagement in MOOCs and suggested five that promote student engagement: problem-centric learning, instructor accessibility and passion, active learning, peer-interaction, and helpful course resources.

Instructional design

The literature has identified questions related to quality of MOOC courses (Chen, 2014) indicating the importance of using high-quality content resources and activities to create an effective instructional design (Amo, 2013). Designing a MOOC should be based on a participatory form to increase understanding of learner diversity and provide learning activities that support different learning styles and needs (Margaryan, Bianco, & Littlejohn, 2015).

In addition, studies have recommended use of quality measures to assess both content and resource design and learner engagement. For instance, Munoz-Merino, Ruiperez-Valiente, Alario-Hoyos, Perez-Sanagustin, and Delgado Kloos (2015) suggested application of the Precise Effectiveness Strategy in a MOOC environment to evaluate effectiveness of learner interactions with educational resources and activities.

Other examples of such frameworks that have been employed to address MOOC quality include: the Quality Matters guide (https://www.qualitymatters.org), iNACOL (http://www.inacol.org) and OpenUpEd (http://www.openuped.eu/images/docs/OpenupEd_quality_label_-_Version1_0.pdf). iNACOL, for example, is a framework that has been expanded to address MOOC. It includes multiple standards and rubrics for measuring quality course design, instruction, and programs.

Assessment

Assessment is an important factor in determining the future success of MOOC (Yousef et al., 2015e), and the ability to evaluate enormous number of learners in MOOC systems is considered a critical issue (Sandeen, 2013a). Most MOOC platforms offer assessment models such as peer assessment or online quizzes (Raposo-Rivas, Martinez-Figueira, & Campos, 2015).

The quality of MOOC assessments has been evaluated by some authors. Admiraal, Huisman and Pilli (2015) examined the quality of the various assessment forms (quizzes, self-assessment and peer assessment of an essay) in three MOOCs and explored how these assessments were related to the final exams. The findings also revealed that completion of weekly quizzes was the strongest variable with respect to predicting final exam results.

Credit

MOOC literature has explored the rapid growth and interest in issues related to the effects of providing credit in MOOC learning environments (Kursun, 2016). Green (2013) indicated that if universities provide MOOC credits, this would create real potential for these certificates to be accepted in the real market. El-Hmoudova (2014) highlighted that providing formal course credit can decrease the dropout rate in MOOC.

Researchers debate how and whether university credit might be offered by MOOC (Bruff, Fisher, McEwen, & Smith, 2013). The literature reveals that, although many MOOC offer certificates or badges for successful completion of a course, there is an absence of formal course credits (Shen & Kuo, 2015). Moreover, a digital badge or a certificate provided by some MOOC platforms contains little value (Jiang et al., 2014), and a successful MOOC completion is not recognized as a formal credit by most universities (Billington & Fronmueller, 2013).

Some educational entities, however, have recently become prepared to grant credits for MOOC. For example, the American Council on Education has approved some of the MOOC courses (Hollands & Tirthali, 2014).

Plagiarism

The copyright issues and its impact on both instructors and learners such as using of copyright materials, course content ownership, and accessibility of open access materials are important factors affecting the future success of MOOC (Marshall, 2014). Many studies investigated plagiarism in MOOC (e.g. North, Richardson & North, 2014) and found the main challenge to be how to validate original work and how to prevent plagiarism. It is important to verify the identity of each student to ensure that a person enrolling in a course is the person who takes the exam. Further research has explored technologies that could be employed to prevent cheating through techniques to ensure fair testing conditions (Meyer & Zhu, 2013), and including technologies that confirm personal identity (Sandeen, 2013a) such as employing signature tracking.

Sustainability

Although MOOCs are providing free courses, they are not free to create or to support. For example, the University of Edinburgh, the first UK institution to join the Coursera platform, has spent on average, from development to delivery, about 45,000 USD on each course (Parr, 2013), thus demonstrating that MOOCs are certainly not free to create or offer, so it is important to identify ways in which MOOCs can generate income to cover such costs and become economically sustainable.

Many research studies have looked at models that would contribute to the sustainability of MOOCs and support MOOCs platforms. Aparicio, Bacao, and Oliveira (2014), for instance, identify sponsorship and data analytics as potential main streams of revenue for MOOCs. Burd, Smith, and Reisman (2014) suggested that charging a fee for certification, connecting students with employers, and charging a fee for extra services are business models that could be appropriate for MOOCs. Their suggestions are aligned with Dellarocas and van Alstyne (2013) who proposed that any institution offering MOOCs should consider various different groups such as students, employers, sponsors, and other platforms who could be expected to pay for MOOCs.

Learning analytics

Learning analytics represent a potential for offering insight into learner and instructor participation in collaborative and interactive activities in MOOCs by providing both individual and general information for supporting learning experiences.

Several studies have suggested applying learning analytics tools to better personalize and fit MOOCs to learners (Daradoumis, Bassi, Xhafa, & Caballe, 2013; Lackner, Ebner, & Khalil, 2015; Tabba & Medouri, 2013) and to support learners in their individual learning experiences (Yousef et al., 2014c). Ebben and Murphy (2014) provide a systematic review of MOOCs, highlighting the growth of learning analytics along with the process of delivering MOOCs.

Product Variables

Product variables are the outputs or outcomes of the educational processes. The results of this study suggest the following two (2) product variables related to MOOCs:

Student dropout rate

MOOC completion is an active area in MOOCs literature, and there is a significant volume of published research on this problem (e.g. Fischer, 2014). Studies indicated that MOOCs are facing high dropout rates (Alraimi et al., 2015; Clow, 2013) with only about 3-10% of students successfully completing the MOOCs (Jordan, 2014).

Many studies have examined the reasons behind MOOCs low retention rates. Clow (2013) asserted that learners pass through the following four stages of dropout in MOOCs associated with a funnel of participation: awareness, registration, activity, and progress. Awareness occurs when potential participants learn about the MOOCs. A small fraction of these potential participants then enter the phase of registration to sign up to take the course. A small fraction of registrants then engage in an activity phase and actively participate in the MOOCs. Finally, only a small fraction of active registrants makes adequate progress and completes a MOOC course.

Other researchers such as Mackness, Waite, Roberts, and Lovegrove (2013) explored the direct factors of autonomy and learner involvement influencing completion of MOOCs. Greene, Oswald, and Pomerantz (2015) also investigated factors that affect learner retention and the characteristics of the participants within MOOCs, revealing that prior experience of MOOC and self-rated commitment to completing a course were the most statistically significant predictors of outcome.

MOOCs quality

MOOCs quality have not yet been clearly defined in the literature and should be more completely investigated (Yousef et al., 2014c). A study by Gamage et al. (2015) is a testament to this matter. They conducted a literature review that studied 4745 peer-reviewed publications in the period (2012-2015) to determine MOOC quality factors, and the findings revealed a significantly small amount of empirical evidence with respect to this issue. Only 26 papers were found to be highly-relevant with respect to examining MOOC quality. From 26 publications, only 7 were provided with proposal frameworks and only 3 offered quality dimensions supported with empirical evidence.

Furthermore, there is a lack of agreement on the most suitable measurement of quality in MOOC (Hood & Littlejohn, 2016) which may explain the limited studies examining critical success factors of MOOC (Gamage et al., 2015). Most of the MOOC literature describes measurement of MOOC quality by assessing completion rates (e.g. Hone & El Said, 2016), but other research (i.e. Littlejohn, Hood, Milligan, & Mustain, 2016) suggests that such a variable (e.g., completion) is not always the goal of individual learners and not really compatible with satisfaction or learner perceptions of successful learning and therefore is not considered an appropriate measure of the quality of learning.

Evaluating MOOC learning requires development of new measures of success and quality that include diversity with respect to both participant and intentions (Bayne & Ross, 2014). MOOC quality can be viewed and measured in various ways. DeBoer et al. (2104) suggested that evaluating participation and achievement in MOOC should be in accordance with the diverse motivations, goal orientations and actions of participants, thus reflecting the dimensions of MOOC quality (Hood & Littlejohn, 2016).

CONCLUSIONS

Although the MOOC movement is gaining in popularity in higher education contexts, this does not necessarily mean that higher education institutions should immediately join the bandwagon. The purpose of this research has

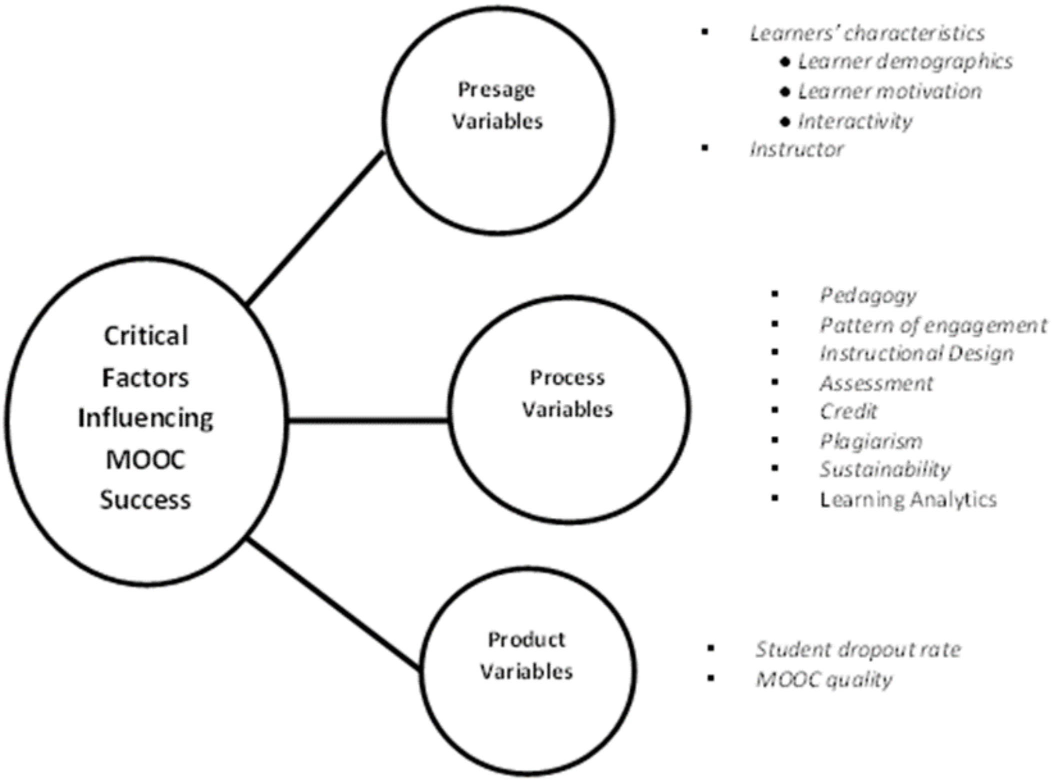

Figure 7. The critical factors influencing MOOC success

been to analyze and map publications related to MOOC research to better understand factors influencing MOOC success. A systematic literature review approach was used to identify and analyze key factors that impact MOOC success.

The findings of this study reveal 12 main factors related to successful implementation of MOOC. They are: Learner characteristic with sub-factors (learner demographics, learner motivation, and interactivity), instructor, pedagogy, pattern of engagement, instructional design, assessment, credit, plagiarism, sustainability, learning analytics, student dropout rate, and MOOC quality. These factors are classified into three levels: presage, process, and product variables, according to Biggs 3P model as displayed in **Figure 7**.

Consideration of these elements will ensure that the MOOC is designed and delivered effectively to ensure meaningful learning occurs and result in learning satisfaction among MOOC learners, thereby achieving success with MOOC systems.

Another important thing worth highlighting is that, as in any e-learning movement, enculturation of MOOC will require full participation from all the actors involved, especially the instructors and learners. Special attention needs to be given to recruitment, training, and support for instructors involved in such initiative (Ghaffar et al., 2016) to ensure that they are ready and fully-armed with the pedagogical approaches needed in planning and implementing MOOC to result in satisfaction and meaningful learning experiences for MOOC learners.

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To Explore the Impact of Medical Education on Sleep Quality toward Quality of Life

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ABSTRACT

Sleep is the basic physiological needs of human beings, while sleep disorder commonly occur in the public. Bad sleep quality would result in bad work efficiency and low quality of life. Insomnia problem is regarded as a disease seriously affecting quality of life in current industrial and commercial societies. Medical education allows students presenting further cognition of self-health concepts and people understanding that proper physical activity could enhance citizens' physical fitness, reduce the occurrence of chronic diseases, and largely help the expenditure of social medical expenses. Apparently, medical education is primary for human health. With experimental design, total 200 students in four classes of the University in Shanghai, as the research object, are proceeded 16-week (3hrs per week for total 48 hours) experimental teaching. The research results reveal the significant correlation between 1.medical education and sleep quality, 2.sleep quality and quality of life, and 3.medical education and quality of life. According to the results and findings, practical suggestions are proposed in this study, expecting to reinforce relevant medical education and draft lifestyles to enhance the sleep quality and quality of life.

Keywords: medical education, sleep quality, quality of life, health

INTRODUCTION

Along with the advance of time, technological and user-friendly products have modern people's life seriously approaching automation and networking. About 60-85% global population therefore show sedentary lifestyle and short physical activity to enhance physical function degradation and mental weakness as well as low quality of life and life meaning. Such a situation has been globally concerned in human health. Sleep is the fundamental physiological need for human beings, as eating, breathing, and drinking water to maintain people's normal life and health status. According to the survey of World Health Organization in 2004, Li et al. (2017) pointed out the factors in sleep, including participation in exercise, environment, work stress, diet habit, drug use, disease, and physical composition. Bad sleep quality would result in bad work efficiency and low quality of life, and long-term shortage of sleep would appear the symptoms of burnout, drowsiness, irritability, memory decline, exhaustion, lack of motivation for work, impaired concentration, and easy conflict with people. Bad sleep quality might result in students' bad performance on schoolwork and exercise, influence emotion, and even cause psychological problems of melancholy. Sleep disorder is a common health problem of the public, in which insomnia problem is regarded as a serious disease to seriously influence quality of life in modern industrial and commercial societies.

Health is the basic need for human beings as well as the primary condition for high quality of life. The establishment of medical education in schools is considered as the fundamental method to enhance national health, as medical teaching allows people understanding the importance of health and factors in diseases to further cultivate the responsible attitudes for personal health and establish correct health behaviors and lifestyles. Medical education could have students show further cognition of self-health and people understand that proper physical activity could enhance citizens' physical fitness, reduce the occurrence of chronic diseases, and largely assist in the expenditure of social medical expenses. Psychologically, medical education could improve individual emotion,

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Contribution of this paper to the literature

- The course and philosophy of medical education in teacher training schools are reinforced so that students pay attention to the cultivation of healthy living habits in the beginning of the school education, understanding the importance and function of medical education, and even being capable of applying it to the health behaviors in adult.
- Schools are suggested to encourage students participating in exercise through health promotion activity to cultivate regular exercise habits, enhance the atmosphere of students participating in exercise, and cultivate the habit of regular exercise so as to enhance personal health and create good sleep quality and quality of life.
- Medical education could be practiced with multi-culture and computer-assisted teaching is preceded through the Internet so that students could acquire health knowledge and resources from the network to achieve the self-learning ability and be responsible for self-health.

stress, self-esteem, physical image, and self-concept. The importance of medical education to physical health is apparent. This study therefore intends to investigate the effect of medical education on sleep quality and quality of life, expecting to draft lifestyles, by reinforcing relevant medical education, to enhance the sleep quality and quality of life.

LITERATURE REVIEW

Medical Education

Zou et al. (2017) regarded medical education as the process people enriching health knowledge and establishing and cultivating habits as well as a life course. Barons et al. (2015) defined medical education as the education or training which could help enhance or develop medical professional knowledge, inference and explanation capability as well as appropriate professional skills to achieve sound doctor-patient relationship standard or ability. Kayaba et al. (2014) revealed that medical education aimed to explain the social activity of the system in which group of people or individuals improved health related behaviors, and, based on the survey, the intervening measure of health information spread was applied to group of people or individuals self-consciously adopting behaviors and lifestyles beneficial to health so as to avoid or reduce the exposure in dangerous factors, help the implementation of disease prevention, treatment, and recovery, and enhance the level of health. Cakici et al. (2015) referred medical education as having people self-consciously adopt behaviors and lifestyles beneficial to health through planned, organizational, and systematic social education activity to eliminate or reduce dangerous factors in health, prevent diseases, enhance health, promote quality of life, and evaluate education effects. Liang et al. (2016) mentioned that the core of medical education was to educate people building health awareness, enhance people to change unhealthy behaviors and lifestyles, and cultivate good behaviors and lifestyles to reduce or eliminate dangerous factors in health. Chiu et al. (2015) indicated that medical education could help people understand health-affected behaviors and self-consciously choose behaviors and lifestyles beneficial to health.

Referring to Lin (2016), two dimensions of health promotion and related behavior are covered in medical education in this study.

(1) Health promotion: Referring to the complex to have behaviors and life conditions approach education and environment support for changing health.

(2) Related behavior: Referring to individual or group behaviors related to health and diseases.

Sleep Quality

Sleep is a normal physiological behavior and the process humans being unconscious of external environment but could awake and recover by environmental stimuli (Lajnef et al., 2015; de Arriba Pérez et al., 2016; Wysocki, Balcerzak, Prus, Niemczyk, Lachowska, 2016; Moon, Kong, Oh, Kim, 2018). Being a primary physiological function to maintain human life, sleep is the fundamental element of life like eating, breathing, and drinking water. Bernert et al. (2014) indicated that sleep was the rest state when the simulation information of brain reticular formation and cerebral cortex appeared less frequent transmission. At the time, people showed less feeling and consciousness of external environment and low alertness and did not easily present instant responses to environmental changes and stimuli. Sleep quality was a complicated physiological health issue, which involved in broad factors, including individual physiological health, genetic factors, emotion and psychology, family and social interpersonal relationship, and physiological characters (Concepcion et al., 2014). Good-quality sleep refers to an adult continuously sleep 6-8 hours per day with sleep latency less than 30min, sleep efficiency above 85%, and sleep interruption time less than 30min to feel satisfaction with sleep and rest content after being awake (Alpert et al., 2015). Mehari, Weir, and Gillum (2014) mentioned that Buysse et al., in 1989, regarded quality, quantity, and indirect sleep related problems as the evaluation of sleep characteristics. Quality contained subjective sleep quality, sense of satisfaction with sleep, and sleep disturbance; quantity covered sleep duration, sleep latency, and sleep efficiency; and, indirect sleep related problems included use of sleeping medication and daytime dysfunction. In other words, sleep quality was individual sense of satisfaction with sleep, which was the comprehensive performance of subjective perception and objective calculation of sleep quantity.

Referring to Chen et al. (2016), sleep quality is extremely important for individual physiological health, well-being, and work efficiency that sleep disorder, sleep efficiency, and sleep duration are included in sleep quality in this study.

Quality of Life

Quality of life is a primary indicator of good life (Li et al., 2017). Individual health factors and satisfaction in life would influence physical and mental health, social economy, and family conditions. Individual perception of the cultural value in the life is related to personal goal, expectation, and standard, including physiology, psychology, society, individual, and environment (Antonishen, 2015) and satisfaction with individual perception of self-importance in the life (Lan et al., 2014). Healthy quality of life referred to individual perception of health factors in life and satisfaction (Szymczynska et al., 2017). Caldwell et al. (2016) indicated that living was a key factor in modern people maintaining life and health, and quality of life should be extremely emphasized as positive development of lifestyles would promote quality of life. Peker (2016) revealed that quality of life related to health was emphasized in medical environment, as an individual might be affected physiologically, psychologically, and socially due to accidents, diseases, or treatment. Cheng (2015) therefore considered that good sleep quality was essential in individual health and life. Rodríguez-Sotelo et al. (2014) pointed out the definition of quality of life in World Health Organization (WHO) as people's perceived life under cultural value systems. Such perception was related to individual goal, expectation, standard, and concern. Grandner (2014) covered physiological health, psychological state, independency, social relationship, personal belief, and environment in such perception. Different experts proposed distinct definitions of quality of life. For instance, the damage and treatment effectiveness of disease were emphasized in medicine, and well-being and satisfaction with life were focused in nursing. Moreover, it could be divided into single dimension and multi-dimension, subjective or objective. Medical effectiveness analysis, clinical medical decision-making, health policy evaluation, and health risk management were applied to medicine (Zhuang et al., 2014).

Referring to Cheng (2015), two dimensions of health status and satisfaction with life are used for quality of life in this study.

Research Hypothesis

Bartels et al. (2015) pointed out various factors in sleep quality, e.g. social change, work stress, lifestyles, individual psychological and health status, living habits, environmental factors, types of diseases, and other physiological symptoms (Chiu et al., 2015). Rose et al. (2014) argued that medical education could improve lifestyles, individual psychology and living habits. Liang et al. (2016) pointed out the importance of health competency for sleep quality because it was necessary to understand the adjustment of pressure, the enhancement of individual psychology, and good living habits being able to prevent diseases, and health competency required medical education. In this case, good health competency required medical education (Lajnef et al., 2015). Based on above inference, the hypothesis is proposed in this study.

H1: Medical education shows significant correlation with sleep quality.

In the study on the correlation between after-disaster insomnia and quality of life, Lin (2016) revealed that people with after-disaster insomnia problems showed worse quality of life than those without insomnia problems. In the discussion of the effect of sleep diseases on the quality of life of elderly patients with hypertension, Cheng (2014) discovered that sleep disturbance would obviously affect patients' quality of life. According to above studies, people with problems in sleep quality would be influenced the quality of life (Alpert et al., 2015). Sofi et al. (2014) stated that bad sleep quality could result in students' bad performance on schoolwork and exercise, influence the emotion, and even cause psychological problems of melancholy later on. Sleep disorder is a common health problem for the public, in which insomnia problem is a disease seriously influencing quality of life in current industrial and commercial societies (Chen et al., 2016). Based on above inference, the hypothesis is proposed in this study.

H2: Sleep quality presents remarkable correlation with quality of life.

Lin (2016) indicated that medical education allowed college students having further cognition of self-health concept to reflect on the physiological, psychological, and social perception of quality of healthy life and effectively enhance quality of life. Cheng (2015) mentioned that medical education could enhance health competency and further affect health, family, and even expenditure for health insurance (Li et al., 2017). Caldwell et al. (2016) pointed out the large effect of health competency on quality of life; especially, changing physical and mental health with lifestyles presented great influence on quality of life, and medical education would enhance useful concepts and strategies for people. It was understood that the enhancement of health competency with medical education was efficient self-care (Zou et al., 2017). Cheng (2015) proposed that medical education could effectively enhance health competency; ones with high health competency would better follow diet control, self-monitoring of blood glucose, and diet control, revealing the better autonomous management of health to further influence quality of life. According to above inference, the hypothesis is proposed in this study.

H3: Medical education reveals notable correlation with quality of life.

RESEARCH METHOD DESIGN

Research Object

Quasi-experiment is preceded in this study. Total 200 students in four classes of the University in Shanghai, as the research object, are proceeded the 16-week (3hr per week for total 48 hours) medical education. The retrieved data are analyzed with SPSS to test various hypotheses.

Analysis

Regression Analysis is applied to understand the relationship among students' medical education, sleep quality, and quality of life.

Operational Definition and Measurement of Variable

Medical education

Medical education is divided into two levels of health promotion and related behavior. The questions are scored with Likert 5-point scale, where 1 stands for extremely disagree and 5 for extremely agree. The overall reliability coefficients appear 0.86 and 0.82 for health promotion and related behavior, respectively.

Sleep quality

Sleep quality contains three levels of sleep disorder, sleep efficiency, and sleep duration. With Likert 5-point scale, 1 stands for extremely disagree and 5 for extremely agree. The overall reliability coefficients show 0.83, 0.87, and 0.84 for sleep disorder, sleep efficiency, and sleep duration, respectively.

Quality of life

Quality of life includes two levels of health status and satisfaction with life. With Likert 5-point scale, 1 stands for extremely disagree and 5 for extremely agree. The reliability coefficients reveal 0.83 and 0.88 for health status and satisfaction with life, respectively.

ANALYSIS AND DISCUSSION

Regression Analysis of Medical Education and Sleep Quality

Regression Analysis is utilized for testing the hypothesis and the theoretical structure in this study. The first regression tests the effect of medical education on sleep disorder. The results show positive effects of health promotion and related behavior on sleep disorder (Beta=0.257, p=0.000; Beta=0.262, p=0.000). The second regression tests the effect of medical education on sleep efficiency, where health promotion and related behavior appear positive and significant effects on sleep efficiency (Beta=0.266, p=0.000; Beta=0.282, p=0.000). The third regression tests the effect of medical education on sleep duration, where health promotion and related behavior reveal positive and remarkable effects on sleep duration (Beta=0.272, p=0.000; Beta=0.278, p=0.000, **Table 1**. Accordingly, H1: medical education presents notable correlations with sleep quality is supported.

Table 1. Regression Analysis of medical education and sleep quality

dependent variable → / independent variable ↓	sleep quality					
	sleep disorder		sleep efficiency		sleep duration	
	Beta	P	Beta	P	Beta	P
health promotion	0.257	0.000	0.266	0.000	0.272	0.000
related behavior	0.262	0.000	0.282	0.000	0.278	0.000
F	17.213		19.611		22.458	
R^2	0.166		0.192		0.217	
adjusted R^2	0.141		0.168		0.188	

*p＜0.05 **p＜0.01

Data source: Self-organized in this study

Table 2. Regression Analysis of sleep duration and quality of life

dependent variable → / independent variable ↓	quality of life			
	health status		satisfaction with life	
	Beta	P	Beta	P
sleep disorder	0.296	0.000	0.287	0.000
sleep efficiency	0.277	0.000	0.294	0.000
sleep duration	0.283	0.000	0.302	0.000
F	25.438		27.183	
R^2	0.244		0.271	
adjusted R^2	0.212		0.243	

*p＜0.05 **p＜0.01

Data source: Self-organized in this study

Table 3. Regression Analysis of medical education and quality of life

dependent variable → / independent variable ↓	quality of life			
	health status		satisfaction with life	
	Beta	P	Beta	P
health promotion	0.269	0.000	0.275	0.000
related behavior	0.311	0.000	0.288	0.000
F	32.164		35.221	
R^2	0.298		0.317	
adjusted R^2	0.271		0.284	

*p＜0.05 **p＜0.01

Data source: Self-organized in this study

Regression Analysis of Sleep Quality and Quality of Life

Regression Analysis is applied to test the hypothesis and the theoretical structure in this study. The first regression tests the effect of sleep quality on health status, in which sleep disorder, sleep efficiency, and sleep duration appear positive effects on health status (Beta=0.296, p=0.000; Beta=0.277, p=0.000; Beta=0.283, p=0.000). The second regression tests the effect of sleep quality on satisfaction with life, where sleep disorder, sleep efficiency, and sleep duration present positive and significant effects on satisfaction with life (Beta=0.287, p=0.000; Beta=0.294, p=0.000; Beta=0.302, p=0.000, **Table 2**. H2: sleep duration reveals remarkable correlation with quality of life is supported.

Regression Analysis of Medical Education and Quality of Life

Applying Regression Analysis to test the hypothesis and the theoretical structure in this study, the first regression tests the effect of medical education on health status. The results show positive effects of health promotion and related behavior on health status (Beta=0.269, p=0.000; Beta=0.311, p=0.000). The second regression tests the effect of medical education on satisfaction with life, and the results reveal positive and notable effects of health promotion and related behavior on satisfaction with life (Beta=0.275, p=0.000; Beta=0.288, p=0.000, **Table 3**. As a result, H3: medical education shows remarkable correlations with quality of life is supported.

CONCLUSION

The research results reveal that medical education allows students achieving the conditions of healthy lifestyles, enhancing the cultivation of regular living habits, and grasping learning opportunity to achieve health promotion and further promote quality of life. Medical education has broadened the source of health knowledge to make better health promotion. Besides, the intervention of medical education could reinforce students' self-health evaluation to more significantly change the sleep quality and quality of life. Medical education could have students perceive the good physical and mental conditions and affect the sleep quality, as a person with physical and emotional problems would not sleep well at night, and ones with bad health conditions would not have good sleep quality. The rapidly changing society could influence students' health behaviors and lifestyles. For this reason, future promotion of medical education should stress on courses conforming to student needs and time trend, expecting to enhance students' physical and mental health aiming at student needs.

RECOMMENDATIONS

By concluding the research results and findings, the following practical suggestions are proposed in this study.

1. The course and philosophy of medical education in teacher training schools are reinforced so that students pay attention to the cultivation of healthy living habits in the beginning of the school education, understanding the importance and function of medical education, and even being capable of applying it to the health behaviors in adult. It would assist in the cultivation of regular habits, presenting correct knowledge and skills, as well as enhancing learning and experiencing the establishment of health behaviors. When facing different environment in the future, necessary medical education materials could then be provided to help promote and establish health living behaviors at various ages.
2. Schools are suggested to encourage students participating in exercise through health promotion activity to cultivate regular exercise habits, enhance the atmosphere of students participating in exercise, and cultivate the habit of regular exercise so as to enhance personal health and create good sleep quality and quality of life. From the aspect of guidance, students are encouraged to engage in regular exercise, establish exclusive leisure sports clubs, thoroughly utilize the after-school time for exercise, arrange social activities among schools, and well utilize sport facilities in schools. Regular emotion related courses could be arranged to have students release emotional pressure through instructors' teaching and enhance well-being and reduce anxiety emotion by participating in the courses to further promote students' sleep quality and quality of life.
3. Medical education could be practiced with multi-culture and computer-assisted teaching is preceded through the Internet so that students could acquire health knowledge and resources from the network to achieve the self-learning ability and be responsible for self-health. Health promotion lifestyles, e.g. "diet health lifestyles", "physical exercise promotion", and "emotion management in health promotion" could be included in the annual health programs for regularly evaluate students' medical health behaviors to enhance students' health responsibility.

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Students Conception of Voltage and Resistance Concepts after Conventional Instruction

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ABSTRACT

The purpose of this study was to determine the level of conceptions reached by students' who learnt the concepts of voltage and resistance with the conventional direct instruction. To answer the research questions, descriptive non-experimental research design was used. A two tier test on the concepts of voltage and resistance was administered to 49 physics and chemistry major first year students in Medda Walabu University, Ethiopia. Students' responses to the five items were qualitatively compared to those found in literature for secondary school and university students. The result showed that the conception of students formed at school level about voltage and resistance were not that much affected even by learning the same concepts at advanced levels and with mathematical rigor at university. Besides, the analysis revealed that students hold multiple opposing ideas regarding the same concept, which contradicts the classical conceptual change perspective. Further, the average conception level reached by the students after learning university level physics courses was "partial understanding". Therefore, attending advanced but traditional course would not enhance students' conceptual understanding. Hence, teachers should have to investigate students' conceptions, as a first step, to subsequently design and implement appropriate instructional interventions.

Keywords: students' conceptions, two-tiered test, voltage and resistance concepts

INTRODUCTION

The plethora of research in students' conception and conceptual change evidenced the fact that many students were found to be clinging to their conceptions other than that of scientists. This negatively affects students' ability in solving real life problems in school curriculum (Tsai, 2003) as well as in their future science/physics related career (Li & Singh, 2016). Lack of success in learning physics in general and theoretical concepts such as force, acceleration, and voltage, is strongly contributing to the low acceptance rate by students and the broader view of physics as difficult subject (Taconis & Kessels, 2009).

Learning is a complex process whereby learners' construct knowledge for themselves from their personal experience and social interactions. Learning concrete as well as theoretical concepts of physics is complicated by the fact that the prior knowledge that students build from their experience usually do not overlap with the scientifically accepted knowledge (Duit & Treagust, 2003). Even though, these students' ideas of a scientific phenomenon were referred to by different terminologies (Treagust & Duit, 2009), they are most commonly called misconceptions. Misconception is defined as the assumption and inaccurate description of particular phenomenon that is created by an individual based on his/her experiences (Martin, Sexton, & Gerlovich, 2002). This occurs in the teaching and learning process as a result of conflict between the knowledge built based on experience and the scientific idea that is introduced in school. In addition to students' personal experience with the physical reality, their social interactions mediated by school textbooks, language used and teachers are all considered as important sources of misconceptions (Kaltakçı & Eryilmaz, 2010). These misconceptions prevent students from the true path

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Contribution of this paper to the literature

- The study showed that the conceptions formed by the students at school level about voltage and resistance were not changed even after learning advanced course.
- It finds out that the high-level physics course taught using the traditional instruction results in an unsatisfactory students' conceptual understanding.
- The study revealed that, students can hold multiple opposing ideas about the same concept instead of 'revolutionarily' replacing one by the other as suggested by the classical conceptual change perspective.

of knowledge and lead one towards misunderstanding and thus unable to achieve the current and future learning objectives.

Children's conceptions, and secondary school and university students' misconceptions in different areas of physics had been studied so far (Bilal & Erol, 2009; Chee, 2010; Dilber, Karaman, & Duzgun, 2009; Li & Singh, 2016; Tanel & Erol, 2008). Studies about students' conceptions of electricity and magnetism concepts at secondary schools and universities were also available (Engelhardt & Beichner, 2004; Kock, Taconis, Bolhuis, & Gravemeijer, 2013; Li & Singh, 2016). In their diagnostic instrument development work, Engelhardt and Beichner (2004) identified a longer list of students' difficulties (including students' misconceptions) in relation to direct current resistive circuit. In their study, secondary school students and university students were also compared with slightly better performance of university students. The work of Kock et al. (2013) summarized specific misconceptions held by secondary school students obtained from many studies over decades. The secondary school students' misconceptions identified in the summaries of Engelhardt and Beichner (2004) and Kock et al. (2013) include: (a) confusion in important concepts such as current and voltage, and attribution of resistance to current, (b) use of the idea that current is consumed in a circuit (or use of unipolar, clashing or shared current models), (c) viewing power supplies as a source of constant current instead of constant potential difference, (d) considering power supply as a source of charge; so thinking that only those bulbs with a direct contact to the power supply will light (e) failing to realize that a change of one element can have an impact on the current in the whole circuit, and (f) considering electric circuit as a sequential system in which only changes before an element will affect that element's behavior, not other elements in the circuit.

In the scares of research in Ethiopia, students were also found to share the same problems as students elsewhere. For instance, the study conducted by Getinet (2007) on Newtonian Mechanics showed that misconceptions are common among university students. Unfortunately, local literature did not cover all areas of physics and students' conceptions. Therefore, Ethiopian students' ideas in most cases including in electricity and magnetism are not known. National examination scores and National Learning assessment results however indicated that there is a serious problem in physics in primary and secondary schools of Ethiopia (Federal Ministry of Education, 2015; Semela, 2010; Shibeshi, Mekonnen, Semela, & Endawoke, 2009). The common characteristic of physics teachers in teaching undergraduate physics is transmitting the logical structures of their knowledge through lecture (Bekalo & Welford, 1999; Getinet, 2012; Mekonnen, 2014). The teaching methods predominantly used by lecturers in physics classrooms and in general in teaching science forced students to become passive recipients and compromised acquisition of process and inquiry skills (Bekalo & Welford, 1999; Esayas, 1995; Treagust & Duit, 2009). According to Getinet (2007), the use of lecture method so as to provide students with bunches of facts, principles, laws, and derivation of mathematical expressions has little benefit to students' conceptual understanding.

Traditional physics instruction has been commonly reported to be ineffective in achieving major goals of physics instruction. That is, influences of the traditional physics instruction on students' understanding of physics concepts, problem-solving skills, and motivation in physics have not been found to be satisfactory by the Physics Education Research community (Taasoobshirazi & Carr, 2008). The research done by Getinet, in conformity with other researchers (Semela, 2010; Shibeshi et al., 2009), also attributed the high level of misconceptions and very low achievement problems to the traditional lecture based teaching method frequently used by physics teachers in schools and universities. These issues have forced researchers to develop alternative teaching methods. There is an extensive literature about the effectiveness of alternative methods. For example, Hake (1998) compared the effect of traditional and interactive-engagement methods on students' conceptual understanding of physics. As a result, the interactive-engagement methods were observed to be significantly better in promoting students' conceptual understanding. Baser and Geban (2007) also demonstrated the effectiveness of conceptual change oriented instruction in grade 10 physics instruction in Turkey.

As many conceptual change theoreticians indicated, Ozdemir and Clark (2007) also contended that instruction and research should not be guided by a single perspective. From one perspective, instructional design for conceptual change should consider the nature of students' knowledge as theory like, that means as a coherent unified framework that may change when the student is dissatisfied with it and a good and powerful replacement is found. The other perspective demands that knowledge to be viewed as ecology which is assortment of quasi-independent elements and therefore, which changes gradually allowing for coexistence of contradictory conceptions at the same time. It is also the recommendation of Treagust and Duit (2009) to take into account the multiplicity of nature in conceptual change domain and therefore either individual perspectives as well as multiple perspectives should be employed.

In Ethiopia, although the government encourages instructors to use active learning strategies, teachers are observed sticking to what they call talk-and-chalk teaching while ignoring the implementation of student-centered instruction (Adula & Kasahun, 2010; Mekonnen, 2014). As a result, the teaching methods commonly used by the instructors in higher education institutions is more of lecturing sometimes supported by group discussions and the like. Hence, the instructors' tendency to implement other conceptual change strategies was not reported in literature. But regardless of the type of teaching method used, the teachers' role is crucial in tackling misconceptions of students since students possess misconceptions at any level.

On the other hand, many of the sources of confusion in science classes are not identified in the classroom as instruction occurs. A research conducted in a recent year has also indicated a wide range of misconceptions in physics which students have apparently formed even after receiving formal instruction (Dalaklioğlu, Demirci, & Şekercioğlu, 2015). It is, therefore, important to investigate students' alternative conceptions concerning specific scientific concepts, as a first step, so that subsequently appropriate instructional interventions can be made. Of course, it is believed that classroom environment which encourages active learning of students (like dialogic teaching in which students are given physical phenomena to discuss and suggest their own explanations and support and rebut claims with evidence) potentially enables teachers in monitoring students' understanding.

According to Osborne (1985), Ross, Lakin, and Callaghan (2000), and Staver (2007), it is crucial in science teaching to identify misconceptions or alternative conceptions of students. Investigating children's ideas is important for both students and teachers (Duit, Treagust, & Mansifield, 1996; Ross et al., 2000). It helps teachers to understand existing levels of students and allows the students to compare existing ideas with new ones. In addition to these, documenting all the alternative conceptions held by students could contribute to lecturers' ability to effect conceptual change as well as benefit and inform science curriculum planning (Driver, 1989). Otherwise, the students would become alien to them being unable to assimilate new knowledge into their existing level. Therefore, teachers need to know ideas of scientists about the concepts to be taught as well as the misconceptions of students in order to promote effective science teaching. The fact that students' conceptions are amenable to instructional strategies were presented by such theoretical works as in Treagust and Duit (2009) and demonstrated very well in the research report by Kock, Taconis, Bolhuis, and Gravemeijer (2015).

Besides the teaching method, in Ethiopia, teachers in general and physics teachers in particular are from low academic status (Semela, 2010; Singh, 2014). Students placed to physics department who are mainly to become secondary school teachers, are those who failed to join other fields of study due to their low scores in university entrance examination. They were placed to study physics without their interest and choice (Getnet, 2007; Semela, 2010). Getinet's study revealed that students placed to physics department had poor ability in school mathematics. Consequently, they were unable to understand the concepts of physics. As a result, their performance in exam was found to be very poor and hence subjected to delay and/or dismissal in their university study. Other studies also report similar results indicating the persistent and deep-rooted problems in the quality of students learning of physics at pre-university level (Shibeshie et al., 2009; Semela, 2010).

In order to identify and measure students' concept understanding, different diagnostic tools have been developed and used. Among them, the two-tier test has been widely used to identify student misconceptions on science concepts (Gurel, Eryılmaz, & McDermott, 2015; Treagust & Haslam, 1986; Wang, 2004). Two-tier tests were considered a great improvement over the previous approaches in that these tests consider students' reasoning or interpretation behind their selected response and link their choices to misconceptions of the target concept (Wang, 2004). Since Treagust (1986) published his seminal work on the development of two-tier test, large number of researchers have developed and administered two-tier diagnostic tests in science subjects (Gurel, et al., 2015). But, in Ethiopia, the usual type of assessment used in classrooms is achievement test. Besides this, although instructors are encouraged to use active learning methodologies, their effort to identify students' alternative conceptions is weak or alternatively not reported in the literature. This study identified and documented first year physics and chemistry degree students' conception of voltage and resistance concepts previously covered in the secondary schools with the use of a two-tier test in Medda Walabu University, Ethiopia. Arising from the issues mentioned above, the following research questions were addressed in this study.

1. What are the levels of conceptions of first year university students about voltage and resistance concepts after taking electricity and magnetism course?
2. Are there differences in conception levels of the students due to some background factors after taking the same course in electricity and magnetism?

3. Are there evidences to conclude that the high-level university physics course improves students' conceptions levels regarding concepts of voltage and resistance?

RESEARCH METHODOLOGY

To obtain relevant information regarding university students' conceptions of voltage and resistance after they studied the topics through conventional direct instruction where the dominant pedagogy was lecturing, descriptive non-experimental research design was used. This is because the study was conducted with an aim to describe a phenomenon or document its characteristics. To identify students' conceptions of voltage and resistance concepts, two-tiered test was administered to first year physics and chemistry major students at the end of the instruction. The test consisted of 5 two-tier questions with two of the items probing students' conception of voltage and the other three (item 3, 4, and 5) probing the concepts of resistance. Four of the items were selected and partially modified from studies investigating students' ideas about simple electric circuits in the literature. Two of the items were selected from Vatansever (2006) and the rest two from Urban-Woldron (2013). The remaining item was prepared by the researchers taking into account the misconceptions found in literature. These items were based on the basic concepts of voltage and resistance that were covered in the secondary school curriculum. In the two-tier diagnostic instrument, the first tier of each item in the test was a multiple-choice question having three to five distracters along with the correct answer and the second tier was composed of a multiple-choice set of reasons for the answer to the first tier. The reasons provided for students contain the correct reason (answer) and possible distracters based on known student misconceptions. The test was administered as a regular test which was part of the continuous assessment of students in the two courses a week after the end of the unit dealing with the topics under investigation were completed. On the other hand, validity was assured by panels of experts comprising university lecturers and researchers familiar with conceptual change researchers. Furthermore, the test was piloted and its reliability coefficient was determined. The coefficient of reliability obtained was 0.73 which is at the acceptable level of reliability in such measurements.

First year physics major and chemistry major students' who have taken the course 'Electromagnetism' and 'Electricity and Magnetism', respectively, at Medda Walabu University as it is demanded by the harmonized university curriculum in Ethiopia (Woldeghebriel & Tenaw, 2013) participated in the study. The total number of students from the physics majors was 17 while those from chemistry department were 32. As a result, all first-year physics and chemistry department students (a total of 49) in Medda Walabu University participated in the study. The participant groups were considered to have almost similar background in the physics learning, particularly in electricity topics as they learned from the same physics curriculum in the high school and no electricity related course were given in the previous university semester. Furthermore, the two courses were more or less similar and are offered based on such text books as Serway and Jewett (2008), and Walker, Resnick, and Halliday (2014). Besides the general introductory approaches in the course for chemistry majors, the only difference observed between the two courses were the dropping of few advanced level physics topics for chemistry majors, which were presumed to be irrelevant for chemistry learning. Hence, the content covered in relation to voltage and resistance in particular was found to be basically identical. The only significant background difference between the two groups is in their entry characteristics. In literature, students who joined the physics department are those with a weaker entry background when compared with others (Semela, 2010; Shibeshi et al., 2009). As depicted in the document obtained from the University, the physics students in this study were assumed to be with somehow inferior motivational levels to join the department than those who joined the chemistry department.

In the data analysis, statistical and qualitative judgments were employed item by item to the first and second tiers separately. So as to see whether most of the students' responses were far from guessing, Chi-square (χ^2) test was conducted. In order to analyze students' level of conceptual understanding, correct response rates were determined and the two groups of students were compared in terms of their highest mean percent correct responses. Percentage distributions among the alternatives given against each item in the first and second-tier were used to determine the predominant conceptions of students. These conceptions were qualitatively compared with results obtained in literature. Finally, in order to determine students level of conceptions, the most familiar method of categorizing with two-tier items that was introduced by Tarakçı, Hatipoğlu, Tekkaya, and Özden (1999) and which was used in similar area of research (Cocstu & Ayas, 2005; Ozkan & Selcuk, 2015) was used. With the rating skim, total conception levels of the two groups of students were determined and statistically compared. Throughout the analysis, a p-value of less than 0.05 was considered to be statistically significant.

RESULTS

Before classifying student's responses into the various conceptions levels, checking for randomness was conducted for the first and second tiers separately. Students responses showed clearer preference to most of the first-tier items except item 5 ($\chi2=8.449$, $p=0.076$) in which they were required to answer conceptual question with a

Table 1. Percentage of correct responses for the first-tier items for all students

	Total (N)	Total (%)	χ^2	P-Value
Item 1	42	85.71	25.00	0.000
Item 2	9	18.37	9.375	0.000
Item 3	22	44.90	0.326	0.475
Item 4	27	55.10	0.735	0.475
Item 5	15	30.61	7.375	0.007

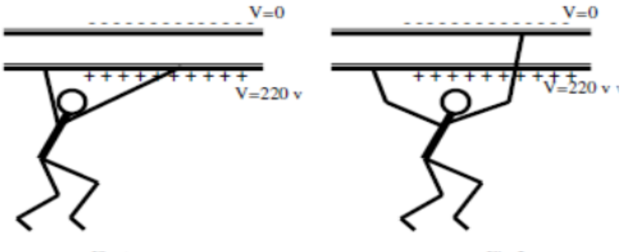

Figure 1. The two figures in item 2 showing two boys hanging from charged parallel plates. Adapted from "*Effectiveness of Conceptual Change Instruction on Overcoming Students' Misconceptions of Electric Field, Electric Potential and Electric Potential Energy at Tenth Grade Level,*" by Vatansever, 2006, p. 95.

circuit having a resistor placed in between two light bulbs. This slight randomness did not render this item worthless as students' responses were confirming what Li and Singh (2016) found for introductory physics students in Turkey. Thus, in general it can be said that all the five items in the first-tier were functioning well in revealing the first-year physics and chemistry students' conceptions about voltage and resistance.

The percentage of correct responses to the first-tier items for the whole first-year students who took the 'Electromagnetism' and 'Electricity and Magnetism' courses at Medda Walabu University is presented in **Table 1**. The analysis presented in **Table 1** was conducted through dichotomous coding of students' responses to the first-tier items, i.e., as correct and incorrect responses.

Both the highest and lowest correct response rates were obtained in relation to the first and the second items. The two items were targeted on students' conceptions about voltage. Even though the items basically involve similar realistic situations about high voltages, their successes in responding to these items were dramatically different. Item 1 was about a bird resting on a high voltage transmission cable while the second one was about boys hanging from high voltage difference conducting plates. In the first item, students were asked about the safety of a bird resting on a high voltage transmission cable. Practically, this is a common observation to students in Ethiopia as it is a country of a large family of birds. Every morning throughout the year birds are seen resting on electric transmission cables wherever one goes. As a result, many of the students (85.71%, $\chi2$=25.000, p=0.001) got the first item correct.

Unlike the content of the first item, item 2 was about unfamiliar and idealistic condition. In this item, two boys were seen to be hanging from charged parallel plates with a potential of 0V and 220V as shown in **Figure 1**. In **Fig. 1** of **Figure 1**, a boy was hanging from a plate with a potential of 220V with his both hands. On the other hand, in **Fig. 2**, a boy is hanging with one of his hands on the 0V and the other on 220V plate. Instead of their observation, which they never have, they had to base their response on their conception about voltage. Thus, only few of the students got this item correct (18.37%, $\chi2$=9.375, p=0.001). From this result, it seems that first-year students still think that high voltage (whether static or alternating) is hazardous instead of the potential difference. The fact that student' responses for the two voltage items were somewhat contradictory even though the physical conditions were almost the same and worth noting.

The other three items were about properties and functions of a resistor in electric circuit. As indicated in **Table 1**, students' correct responses were distributed in the intermediate range. Responses of physics and chemistry students to these three first tier items taken together and marked as correct and incorrect appeared to be randomly distributed except in the fifth item for which there were only 30.6% (15) correct responses ($\chi2$=7.375, p=0.007). Students' correct responses to item 3 and 4 were relatively higher (44.9%, $\chi2$=0.326, p=0.048 and 55.1%, $\chi2$=0.735, p=0.475, respectively) than that for item 5. However, it should be recalled that students' response distributions for these items over the four and five alternative answers were found to be none randomly distributed. That means the first-year physics and chemistry students in this study made distinct choices even though those choices were mostly incorrect.

The first-year students, who had already taken the calculus based electricity and magnetism courses in which they had opportunities to mathematically solve several problems involving resistor, did still believe that either the

Table 2. Comparison of correct response distribution for the first-tier items by department

	Total (N)	Total (%)	Chemistry (%)	Physics (%)	Comparison by Department	
					χ^2	P-Value
Item 1	42	85.71	87.50	82.35	0.240	.624
Item 2	9	18.37	18.75	17.65	0.009	.924
Item 3	22	44.90	50.00	35.29	0.970	.325
Item 4	27	55.10	65.63	35.29	4.128	.042
Item 5	15	30.61	37.50	17.65	2.060	.151

Table 3. Distribution of reasons given by students for their responses of first-tier items

	A	B	C	D	χ^2	P-Value
Item 1	-	12	32	5	24.041	.000
Item 2	3	13	14	19	11.000	.012
Item 3	16	27	6	-	13.510	.001
Item 4	-	15	16	18	13.939	.003
Item 5	10	14	16	9	2.673	.445

resistance of a resistor increases with its size (36.7%) or size has nothing to do with the magnitude of the resistance (18.4%). In items 4 and 5, students were given a problem in which the function of a resistor in electric circuit was asked with the resistor at different places with respect to a lamp in series circuit. In item 4, a little more than half of the first-year university students correctly answered that increasing resistance in a circuit reduces the current and consequently resulting in a decrease in the brightness of a lamp. It was observed that this response was statistically significant (55.1%, $\chi 2=0.735$, $p=0.475$), though it was marginally. Still a significant minority of the first-year students (32.6%) believe that there is no relationship between the brightness of the lamp and the resistor in series circuit. Students' responses to item 5 partly corroborated the finding related to item 4 and also bring about current consumption model of student conception. Similar observations were made for introductory physics students and PhD students in Li and Singh (2016) and also for high school students in the study conducted by Kock, et al., (2015).

In addition to the correct/incorrect response distribution of all students in this study, comparison was made between chemistry students who took 'Electricity and Magnetism' course and physics students who took 'Electromagnetism'. This comparison was needed to see if the difference in their entry profile had resulted in any difference in their voltage and resistance conceptions.

In general, physics majors are considered to have lower profiles at entry (Getinet, 2006; Semela, 2010) than students joining any other fields. Therefore, the data in **Table 2** here seemed to be evidencing the implication of the weaker academic background of physics students when taken from the surface. However, chi-square test revealed that there was no statistically significant difference between the two groups at least regarding their response rates to the five first-tier items. The only apparent significance was in relation to item 4 which was related to the role of a resistor in series circuit. Even here, the statistically significant difference had no practical significance (Odds ratio = 0.987) to imply that physics students were inferior to chemistry students in any meaningful ways.

In order to diagnose the underlying students' conceptions on which they based their responses to the first-tier items, a set of reasons were provided to them in the second-tier to each item. In **Table 3**, the distributions of first-year students in this study across the alternative explanations are presented.

As can be seen in **Table 3**, students' choices of reasons for their answers to the first-tier questions were distinctly distributed. A fussy reasoning was given only in relation to item 5. In the second tier of item 1, the first-year students clearly showed that they did not consider the voltage in the electric transmission cable as low voltage by rejecting the given alternative "A". In addition, majority of the students (N=32, 65.3%) clearly made distinction between voltage and potential difference by choosing alternative "C". Alternative "C" which was actually the correct reason, states that "Birds do not get hurt because there is very small and negligible electric potential difference on their legs."

In item 2, where majority of the students' failed to answer the first-tier correctly (81.6% failure rate), their reasons were also varied. The most favored reason in this item was choice "D" (N=19, 38.8%) which states "boys are in danger in both figures, but the danger in Fig.1 is greater because the potential difference between the hands of boy in Fig.1 is greater."

The students' reasons distribution in item 1 and 2 taken together implied that these students had lots of naïve conceptions in relation to the concepts of voltage and potential difference. **Table 4** summarized the misconceptions held by first-year students even after learning through a high-level physics course in electricity and magnetism.

Table 4. Some of students' misconceptions about voltage

Item	Conception	Mean choice
Item 1	No potential difference in conductors	24.5%
Item 1 & 2	High voltage is dangerous	46.9%
Item 2	High voltage is dangerous when there is connecting wire	6.1%
Item 2	There is potential difference between two points even if the points are at the same high voltage	18.4%

Table 5. Percentage of correct responses for the second-tier items by department

	Total (N)	Total (%)	Chemistry (%)	Physics (%)	Comparison by Department	
					χ^2	P-Value
Item 1	32	65.31	71.88	52.94	1.757	.185
Item 2	13	26.53	28.13	23.53	0.120	.729
Item 3	27	55.10	62.50	41.18	2.040	.153
Item 4	18	36.73	31.25	47.06	1.194	.275
Item 5	14	28.57	28.13	29.41	0.009	.924

The abundance of these conceptions was as high as 46.9% and the distinct misconceptions were still existent (6.1%) even if students had taken an advanced physics course. These conceptions are in line with what had been found from secondary students (Kock et al., 2015) as well as university introductory physics students (Li & Singh, 2016). This means, the learning of physics at a higher level did not help these students at least to reduce their misconceptions with respect to the concept of voltage.

As presented in **Table 3**, first-year chemistry and physics students supported their responses to the first-tier items pertaining to the concept of resistance (item 3, 4, and 5). The reason that got most preference (55.1%, $\chi 2=13.510$, $p=0.001$) by the students is the correct reason for item 3 that reads as "brightness of the lamp increases, when the resistance in the wire is smaller". However, it is important to note that only 45% of the students got the first-tier of this item right while 55% have got the right reason. This may be a sign of difficulty in applying knowledge to solve a concrete problem. Correct reasons for item 4, where the effect of resistor in a simple circuit is asked was found to be as high as 36.7% ($\chi 2=13.939$, $p=0.003$). However, assertions such as that "change of the resistor only influences the brightness of the lamp if the lamp is behind the resistor" which is implicit form of the conception that resistor consumes current and that "it is the same battery in the circuit, and therefore, the same current is delivered" were also rated nearly as high as the correct reasoning. This means, students hold similar misconceptions about the functions of resistors in electric circuits and properties of voltage even after learning through advanced level course.

Except in item 5, students clearly selected non-random choices to support their responses. Item 5 kept being difficult for these students both in first-tier and second tier cases. As it is evident in literature (Bilal & Erol, 2009; Engelhardt & Beichner, 2004), the first-year students in the current study (N=10, 20.4%) were still found to think that larger resistance means larger current. About the same number of students as in item 4 (M=16, 32.6%), used their "same battery" idea to justify their response in the first-tier. Therefore, despite taking an advanced physics course in which they were solving large number of mathematical problems based on similar contexts, the first-year physics and chemistry students still have misconceptions in voltage and resistance areas.

Studies conducted in Ethiopia, as described above, suggested that Physics majors would come to the field with inferior profile compared with others (Getinet, 2006; Semela, 2010). Therefore, the participants in this study were expected to have difference in the degree of having the correct conceptions related to the tested items: voltage and resistance. To see this, comparison was also made between physics and chemistry majors in terms of the distribution of correct reasons among them (**Table 5**).

As seen in **Table 5**, the highest and lowest correct response rates for the reasons were related to item 1 and 2, respectively. Even if as high as 85.7% students correctly answered the first-tier question in item 1, only 65.3% could substantiate their response with the correct reasoning. In the case of item 2, more proportion of students (26.5%) had the correct reasoning than the proportion of students who correctly answered the first-tier part. From the data in **Table 5**, it appears that chemistry majors scored higher in some of second-tier items (item 1, 2, and 3) and physics majors with the rest (item 4 and 5). Nevertheless, none of these differences were found to be statistically significant to warrant the expectation of lower status of physics majors than chemistry majors.

Table 6 presents the summary of some of the common misconceptions related to resistance found in this study.

Table 6. Some misconceptions of first year students about resistance and its functions in simple electric circuits

Item	Conception	Mean choice
Item 3	Thicker wires have larger resistance even if the length of the wires kept constant.	34.7%
Item 3 and 4	Large resistance increases the brightness of a lamp in a circuit.	28.6%
Item 3	The resistances of connecting wires do not affect the brightness of a lamp in a circuit.	16.3%
Item 4 and 5	The location of a resistor has an impact on the brightness of a lamp. Resistor on the battery side consumes the current.	26.5%
Item 4 and 5	The property of a circuit is determined by the battery but not by the resistance in the circuit	31.6%

Table 7. Percentage of students on the different conception levels with respect to voltage and resistance concepts

	Department	Item 1	Item 2	Item 3	Item 4	Item 5
No Understanding	Chemistry	9.40	68.80	31.30	28.10	56.30
	Physics	17.60	76.50	47.10	41.20	64.70
	Total	12.20	71.40	36.70	32.70	59.20
Specific Misconception	Chemistry	18.80	3.10	6.30	40.60	15.60
	Physics	29.40	0.00	11.80	11.80	5.90
	Total	22.40	2.00	8.20	30.60	12.20
Partial Understanding	Chemistry	3.10	12.50	18.80	6.30	6.30
	Physics	0.00	5.90	17.60	23.50	17.60
	Total	2.00	10.20	18.40	12.20	10.20
Sound Understanding	Chemistry	68.80	15.60	43.80	25.00	21.90
	Physics	52.90	17.60	23.50	23.50	11.80
	Total	63.30	16.30	36.70	24.50	18.40

The misconceptions held by the first-year students vary in abundance from 16.3% for "connecting wires have no effect in a circuit" to 34.7% for "large size means large resistance". Just like the misconceptions related to voltage, the first-year students have the same common misconceptions found elsewhere (Bilal & Erol, 2009; Kock et al., 2015; Li & Singh, 2016). This showed that misconceptions were found with high abundance after the respondents completed the introductory university physics course.

The main objective of this study was to determine the levels of conceptions about voltage and resistance of the first-year university students. In order to determine the conception levels, the coding and rating skims used by Cocstu and Ayas (2005), Ozkan and Selcuk (2015), and Tarakçı et al. (1999) was used. According to this categorization, based on students' responses in the first and second-tier conceptual test items were labeled as "Sound understanding" with 3 points weight, "Partial understanding" with 2 points, "Specific misconception" with 1, and "No understanding" with the least 0 weight. The percentage distribution of first-year students over the different levels are presented in **Table 7**.

In general, the first-year students populated much of the lower end of the scale (No Understanding) and to some extent, the Sound understanding end as well. Relatively large proportion of the first-year students (63.3%) showed sound understanding of the concept of voltage in a rather familiar realistic condition. But, the same could not be demonstrated for the same concept in the case of the same but none familiar condition - the hanging of boys from a high voltage transmission cable. In fact, the larger proportion of "No Understanding" (71.4%) was observed in this case. On the other hand, only 36.7% of the first-year students demonstrated that they have "Sound understanding" of the property of resistance. However, 63.3% of these students were found to have one or the other problem in relation to the concept of resistance, with 36.7% of them still within the "No understanding" level. When it comes to the functioning of a resistor in a simple circuit, only 24.5% of these students showed that they have clearer understanding. Hence, it can be observed that the understanding level reached by the first-year students were still the same as that of secondary school students elsewhere (Bilal & Erol, 2009; Kock et al., 2015).

From the data in **Table 7**, it can also be observed that there is difference between chemistry and physics majors with a mean deviation of 12.13%. Mostly chemistry students seemed to highly populate the higher levels than the lower levels. Nevertheless, in order to see if these students do really have difference in their conception levels, their mean scores according to the weighting for different levels was calculated and compared. Independent sample t-test was used to compare the conception level means of the chemistry and physics students as presented in **Table 8**.

Table 8. Comparison of mean score of students with respect to the level of conception by department

Department	N	Mean (M)	Std. Deviation (SD)	Std. Error Mean	df	t	p-value
Chemistry	32	7.031	3.0742	.5434	47	1.343	.186
Physics	17	5.765	3.2697	.7930			

Equal variances assumed: Levene's Test (F=0.411, P>0.05)

Even though the chemistry students mean score (M=7.03, SD=3.074) appeared to be higher than that of the physics majors (M=5.76, SD=3.270), the t-test revealed that the observed difference was not statistically significant (t=1.34, p=0.186). This result is again surprising as the lower profile physics students during entry to the program should have been expected to perform lower than the better entry profile chemistry students. The very low mean scores (the maximum possible was 15 points) of both the chemistry and physics major imply that university students still have as many misconceptions as secondary school students even after passing through the traditional but high-level physics course.

DISCUSSION AND CONCLUSION

Now a day's physics education and science education in general is assumed to have conceptual learning as an important goal of instruction (Kock et al., 2015; Treagust & Duit, 2009). In this research, we wanted to determine the level of conceptual understanding reached by first year university student after studying two units involving the concepts of electric potential (voltage) and resistance. The first-year students' conceptions about these concepts were investigated using a two-tier test and assigning their responses into different conception categories and different conception levels using the skim commonly used in misconception studies (for example in Ozkan & Selcuk, 2015). After identification of first year students' conceptions, comparison with those found in literature at secondary school (Urban-Woldron, 2013; Vatansever, 2006) and university (Li & Singh, 2016; Ozkan & Selcuk, 2015) levels were made.

The most important students conceptions identified in this study were (a) although there are clear distinctions between the concepts of potential and potential difference, still high voltage not potential difference is hazardous; (b) there is no potential difference between points within a conductor although there is a potential difference between the points even when the conductor is maintained at the same high voltage; (c) thicker wires are more resistant than thinner ones; (d) larger resistance means larger current; (e) resistance of connecting cables have no effect on a circuit behavior; (f) the location of a resistor in a circuit determines its effect; a resistor on the battery side consumes the current to a lamp; and (g) the current in a circuit is determined by the battery not by the resistance.

Comparison of these misconceptions with those found in relevant literature revealed that the same old conceptions (Bilal & Erol, 2009; Engelhardt & Beichner, 2004; Kim & Pak, 2002) were still abundant among them even after taking the university introductory physics course. For example, the conceptions about voltage found here were the same as those in Vatansever (2006) among secondary school students. Most of the other students' misconceptions found in this study were also similar to what Tsai (2003) found from grade 8 students and which were resistant to change with traditional instruction. Some degree of resemblances for some of the misconceptions found in this study was also found with those studies in universities elsewhere (Engelhardt & Beichner, 2004; Li & Singh, 2016).

In their review of the literature relevant to this area, Kock et al. (2015) summarized students' misconceptions related to the concepts of voltage and resistance in simple circuits. In this study, the Kock et al. list was found to be confirmed by the above list we found among first year physics and chemistry students after learning two units at a higher level. This result suggests that even if students learn physics at a university level with a higher-level curriculum, the conception students formed at school level about voltage and resistance concepts were not affected. This is of course not only with first year university students; even PhD students in physics do share the misconceptions to some extents (Li & Singh, 2016). This is an indication of failure of the content driven curriculum which was developed based on the abstract logic of the subject matter instead of taking into account students' ideas and learning difficulties. Instead of targeting conceptual learning of such basic concepts as voltage and resistance, it university physics courses speed up the mathematical representations and abstract manipulations of the concepts. Under such conditions, the students' misconceptions are overlooked during instruction and remain to limit their understanding and further progress in their learning (Kock et al., 2013).

Treagust and Duit (2009) acknowledged that science teaching at every level of education should aim at creating conditions for students to conceptually learn the content. If conceptual change and conceptual learning are desired, attention must be given to the ideas and problems students bring to the classroom. To this end, the classroom culture where students are treated as passive recipients of the high-level content knowledge mediated by the teachers talk should be replaced by the one including the social processes of knowledge building and the epistemic side of the curriculum (Kock et al., 2013; Duschl, 2008).

The other related finding in this study was the fact that the first-year students had contradictory views about the same concept: concept of voltage. When they were given a voltage problem in a very familiar situation (birds on high voltage cable) majority of them did not say high voltage is dangerous in any conditions. Nevertheless, when the same problem was presented to them in an unlikely and unfamiliar case of a boy hanging from a plate maintained at a high voltage, most of them depended on their "high voltage is hazardous" conception. This fact is at odds with the classical conceptual change model of Posner and his colleagues (Treagust & Duit, 2009) which assert that students have a single conception that changes revolutionarily whenever an intelligible, plausible, and fruitful conception is available. Instead, this seems to evidence the second perspective of knowledge which asserts that students' knowledge is more like conceptual ecology of quasi-independent elements (Ozdemir & Clark, 2007). If conceptual change were to occur according to the classical epistemological recommendation, such contradictory ideas would not have co-existed. According to this view, when students are confronted with contradictory conditions with their existing ideas, dissatisfaction which leads to the revolutionary replacement of the previous idea would occur. However, the finding in this study revealed that even contradictory ideas do co-exist instead of one replacing the other. But, as Ozdemir and Clark (2007), Treagust and Duit (2009) argued that conceptual change instruction should not be guided based on a single perspective. They recommended that research and instruction in conceptual change should at least include the classical- epistemological, ontological and affective orientations.

In this research, the first-year students' conception levels were determined using a scale with a maximum point 3 (sound understanding) to a minimum of 0 (no understanding) as in Ozkan and Selcuk (2015). A low mean score of about 6.59 out of 15 maximum point was obtained which could be translated to a score of 2.2 points on the above scale and which means the average level of understanding reached was far from "sound understanding". Hence, we conclude that the average conception level reached by the first-year students after learning two units on the concepts of the test was "partial understanding". It can be observed that the understanding level reached by the first-year students were still the same as that of secondary school students elsewhere (Bilal & Erol, 2009; Kock et al., 2015). This result confirmed the finding of Duit and Treagust (2003) which implied that attending advanced but traditional university physics course would not help students to improve their physics understanding. Başer and Geban (2007) also showed that misconceptions held by students before and after traditional physics instruction were the same. Hence, one cannot escape here from concluding that the traditional but high-level physics course would not help in conceptual physics learning. This is in consonance with the findings obtained in literature (Bilal & Erol, 2009; Duschl, 2008; Li & Singh, 2016).

Despite the presumed academic background differences between the chemistry and physics majors, no statistically significant difference in their conception levels were obtained. As no progress was observed between school and university studies, in this research, we cannot attribute this lack of differentiation among the first-year students to the normalizing effect of instruction. What was found in this study was that university students still had as many misconceptions as secondary school students even after passing through the traditional but high-level physics course. This is in line with the findings obtained in literature (Duit & Treagust, 2003; Li & Singh, 2016; Ozkan & Selcuk, 2015). Therefore, instead of normalizing the difference among first year students', we found that the high level physics course did not result in better students' conceptual understanding. Since such courses were commonly taught using the traditional methods, teachers were not utilizing well tested conceptual change teaching methodologies such as those discussed in the science conceptual change literature as Ozkan and Selcuk (2012) and Treagust and Duit (2009). As a result, we conclude that physics teachers' do not give due attention to students' ideas and misconceptions in their traditional direct teaching lessons. Hence, instead of attaching student's failure to their poor entry background, instructors have to look for an opportunity to expose the less able students to a variety of conceptual change teaching strategies which help them learn and understand the basic concepts of the topics being taught.

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Effects of The Application of Information Technology to Art Education Therapy on University Students' Self-Concept and Peer Relationship

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ABSTRACT

The development of information facilitates people's life and impacts and influences traditional teaching methods. Information technology integrated into modern teaching and scientific concept learning therefore plays a critical role. The advance and development of economy and technology have the society tend to diversity. Under such a situation, university students encounter the impact of diverse value. Students with low self-concept and alienated peer relationship urgently require proper guidance for the effective improvement. Art education therapy stresses on art teachers paying attention to students' individual difference and identifying the characteristics of students' emotional disturbance and anomalous behavior for effective referral. Total 98 university students in two classes of LuXun Academy of Fine Arts in Shenyang City, Liaoning Province, as the research objects, are proceeded 16-week (3hr per week for total 48 hours) art education therapy with information technology. The research results show significant correlations between 1. art education therapy and self-concept, 2. art education therapy and peer relationship, and 3. self-concept and peer relationship. Finally, suggestions are proposed according to the results, expecting the intelligent instruction of school education to really inspire university students' personality growth to achieve the goal of holistic education.

Keywords: information technology, art education therapy, self-concept, peer relationship

INTRODUCTION

Information technology integrated modern teaching and scientific concept learning plays a primary role due to the explosion of knowledge and the changing technology in past years. The major value lies in satisfying the needs for various education concepts, conforming to students' individual needs, and adapting to individual differences. It therefore is a tool assisting in teachers' teaching and students' learning and a method attempting to improve teaching. The advance and development of economy and technology in Taiwan have the society tend to diversity to change the lifestyles and learning environment of family and schools. Under the situation, students encounter the impact of diverse value, and parents and teachers perceive the difficulty in the roles. Although guidance is gradually emphasized in schools, short of guidance resources in schools is the dilemma in current education. Students' deviant behaviors at schools, e.g. hyperactivity, autism, inferiority, anxiety, shyness, bad emotion control, violence, inquisitiveness, snitching, and bad living habits, often result in other classmates not being willing to get along with them. Such students, without proper guidance and assistance, would not integrate into groups and easily become label characters in the classes and lose the self-confidence, and even develop negative self-concept. Such students with low self-concept and alienated peer relationship urgently require proper guidance for the effective improvement.

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Contribution of this paper to the literature

- To apply various multimedia exploration activities with information technology, increasing contact with students, and being family art activity could promote university students' self-concept and self-confidence and the acquisition of achievement.ar with materials, teachers could design suitable art education therapy courses by communicating with the tutors and parents and understanding students' background to enhance students' self-concept and peer relationship.
- Education units could emphasize the study on art education therapy and broadly open the channels for relevant courses or seminars.
- Art teachers are encouraged to cooperate with therapy teachers to really develop the interdisciplinary characteristics.

Art could release people's emotion. Students' inner world and needs could be understood through the art activity process. For students, art is one of subjects with less pressure in school education and the course design is more flexible. In the ordinary teaching and students' life guidance, students' living experience is closely related to the art creation, and students' art creation process and works also respond the psychology state at the time. After the 20th century, psychologists started to treat people with psychological and physiological disorder. Art education therapy stresses on teachers paying attention to students' individual differences and identifying the characteristics of students' emotional disturbance and anomalous behaviors for effective referral. Information technology is therefore applied to art education therapy in this study to understand the effect of art education therapy on university students' self-concept and peer relationship, expecting that school education could present intelligent instruction and really inspire students' personality growth to achieve the goal of holistic education.

LITERATURE AND HYPOTHESIS

Information Technology Integrated Teaching

Information technology is a new system or new communication method developed with digital electronic media, i.e. the application of computers, multimedia, and network media to collect, process, store, and transmit texts, graphs, images, and voice (Clark & Mayer, 2016; Pontes & Albuquerque, 2017). Information education is developed from computer-aided teaching and computer course practice to information integrated teaching. The role of information changes from "information as a teacher" to "information as learning partners". Jin et al. (2014) indicated that information technology integrated teaching was to integrate information technology into curricula, materials, and teaching and have technology become the essential teaching and learning tools, i.e. the use of technology being a part of daily life and being extended to regard information technology as a method or a program for searching for problem solutions anytime anywhere. Atenas and Havemann (2014) considered that information technology (the application of information equipment, multimedia, network media to collect, store, and transmit texts, images, and voice) was to combine new systems or new communication with the entire teaching activity (goal, student, content, environment, teacher) when applying it to various subject teaching activity. Such a new teaching method presented the application with interactivity, reproducibility, computability, and instrumentalization. Ihmeideh (2014) referred information technology integrated teaching as computer multimedia or network technology, which presented the functions of digitalization, multiple stimulation of audio and video, accessibility, fast processing, and easy communication, i.e. matching the needs for teaching contents and teaching strategies, applying the characteristics of computer multimedia network, regarding information technology as teaching tools, and increasing more flexibility than traditional didactic teaching to provide more two-way communication opportunities for students' learning.

Art Education Therapy

Kuo and Chao (2014) interpreted art education therapy as a psychological therapy, providing non-verbal expression and communication opportunities for the party exploring personal problems and potential through non-verbal and verbal expression and art experience. Conejeros and Mansilla (2014) pointed out art education therapy as the general term of "art" and "therapy", while "communication" and "insight" were more important than art creation. Maeng and Lee (2015) indicated that art education therapy regarded art as the bridge of individual intrinsic and extrinsic experience that the party could release uncomfortable emotion through creation and clarify old experience. In the process realizing ideas into images, individual needs and emotion were delivered, through sharing and discussion to integrate the personality. Agarwal and Mittal (2014) mentioned that, for the practice of art education therapy in ordinary classes in a school, teachers had to present the competency of art education, counseling, and special education in order to be competent in the art education therapy work. Molaee and Dortaj

(2015) considered that art teachers for the practice of art education therapy should carefully utilize the therapy functions of various media, grasp timing, and apply it to distinct curriculum design to help students' common learning and happy growth in art courses

Referring to Cai et al. (2014), "art education therapy" is divided into following dimensions in this study.

(1) Curriculum design: To plan flexible courses with little structure, according to students' physical and mental development at various stages, to enhance students' intrinsic self-exploration.

(2) Curriculum content: To pay attention to course integration, combine various seasons, festivals, activities, and students' life experience to induce students' exploration with open-ended questions or subjects.

(3) Group dynamics: A teacher in the "art education therapy" course is like a group leader designing teaching and enhancing individual growth, based on the group dynamic.

(4) Multiple assessments: To get rid of work-oriented evaluation in traditional art education, children's performance in the activity process is evaluated with 5-scale or multiple evaluation dimensions.

Self-concept

Lubega et al. (2014) regarded self-concept as the core to construct personality. Niknejad and Rahbar (2015) defined self-concept as the idea and emotion to which an individual regarded self as an object for reference. Baran (2014) defined self-concept as a relatively stable self-attitude, which reflected individual description and evaluation of the behavior and quality. Subasi et al. (2017) regarded self-concept as individual opinions about subject self to object self, meaning the sum of individual perception of self, including individual understanding of the personality, ability, interest, and desire, the relationship between individual and environment, individual experience in dealing with affairs, and the understanding and evaluation of life goals. Jude et al. (2014) referred self-concept as the sum of personal idea, emotion and attitude, i.e. an individual attempting to explain self and establish schema to organize the impression, emotion, and attitude towards self. In short, it was the overall opinions of an individual toward self.

Referring to Huang and Chuang (2016), self-concept is the perception of and attitude towards personal image and personality traits and is "conceptual construct", i.e. an individual perceiving and believing in self and performing in the behavior system to become individual model. Three dimensions of self-concept are further explained.

(1) Body image: The belief in personal physical and psychological needs and the provision of self with physical space.

(2) Social self: The belief in individual roles in the society to further expand self to the social space.

(3) Person identity (self- identity): The belief in certain belief, ideal, and value systems. Person identity provides the third space, i.e. psychological life or spiritual life, to have a person exist as the value.

Peer Relationship

Manek et al. (2017) proposed peer relationship as the mutual relationship between individual and peers. Peer relationship, also called "social relationship" or "friend relationship", was regarded as an important interaction in society or schools. Khalid et al. (2014) pointed it out as the interaction situation and degree of people at equivalent status. Saelao et al. (2016) also revealed that peer relationship was the interaction process and situation in peer groups. Alickovic and Subasi (2016) pointed out two simple characteristics of peer relationship as the obvious distinction with other interpersonal relationship that two parties with different fairness and rights were generally equal in the peer relationship, and the rights were balanced. Uysal and Gunal (2014) regarded peer relationship as a kind of interpersonal relationship and the basic interpersonal relationship for individual development and socialization. Peer relationship presents great influence on youngsters.

Referring to Lee and Hao (2015), the following dimensions for peer groups are used in this study.

(1) Self-understanding: Peers are the reference group of students' behavior comparison. Peers are like a mirror with which students could know themselves from others' responses to form self-concept.

(2) Social skill: Peer performance provides partial demonstration and reinforcement for students. Parent and teacher authority could regulate student behaviors, but the value judgment and preference choice of peer group could have students actively revise the behavior, change the thoughts, and learn to communicate and express personal opinions, social skills to get along with others, and problem-solving ability.

(3) Support and belonging: Cohort status is equal. Support and belonging from peers for students lacking family warmth or sibling interaction could not be replaced by parents. Students often require peer identity and belongingness for the psychological satisfaction.

Research Hypothesis

Wu and Kuo (2014) argued that art creation was therapy. The art creation process could release emotional conflict, purify emotion, and enhance the party's insight to assist the party in self-recognition and self-growth and enhance students' self-concept. Castellanos Nájera (2015) indicated that art education therapy integrated psychological analysis and art essence, paid attention to the psychological process and members' psychological dynamic in the creation process, and carefully arranged art activity and media, expecting to release members' psychological energy through art creation and share and assist members in self-awareness to achieve the integration of personality and self-concept. Molaee and Dortaj (2015) regarded art therapy as an interesting therapy to attract students' active participation. Students' works could reflect the talent, physiological and competence development, and the relationship between self-concept and external real world or daily life environment. The following hypothesis is therefore proposed in this study.

H1: Art education therapy shows significant correlations with self-concept.

Kuo and Chao (2014) stated that applying art therapy to schools could construct students' positive interpersonal relationship and assist students' in the physical and mental integration and healthy development of personality. Cai et al. (2014) indicated that art education therapy, through course planning, combined students' life experience and regarded art as the bridge to express individual intrinsic and extrinsic experiences. Ibáñez et al. (2014) proposed the aim to enhance students' aesthetic experience and, through humanistic art teaching activity, integrate students' learning experiences, release the physiological constraint and emotional disturbance so that students could develop bright and positive self-concept and enhance peer relationship. Alickovic and Subasi (2016) mentioned that art education therapy, following the principles, assisted students in self-exploration, self-acceptance, self-opening, and self-understanding, through the expression of art media, in the secure and reliable situations, as well as enhance cognition and dignity and harmonize intrinsic and extrinsic conflicts to achieve the effects of stable emotion, emotional sublimation, and enhancement of behavioral adaptation. Moreover, Maeng and Lee (2015) explained it to stimulate group interaction through creation activity and the arrangement of sharing and discussion to enhance mutual understanding among peers and further improve peer relationship that it was suitable for art education in ordinary classes. Accordingly, the following hypothesis is proposed in this study.

H2: Art education therapy reveals remarkable correlations with peer relationship.

Lee and Hao (2015) mentioned that students had to learn social ability and social norms as well as to establish value and self-concept in the interpersonal interaction. Interpersonal relationship contained various interactions among people, such as parent-child relationship, peer relationship, teacher-student relationship, and parent-teacher relationship. Sanjay (2016) explained self-concept as to generate interpersonal relationship with others through self-opening. With "Johari Window", people could understand the depth of personal and others' understanding of self. Johari Window includes two dimensions of "extrinsic self", as individual image in others' minds, and "intrinsic self", as self-understood image. Huang and Chuang (2016) indicated that self-concept generated interpersonal relationship with others through the opening of such two dimensions. Generally speaking, students with higher self-concept present better interpersonal relationship, self-confidence, adaptation, and more stable emotion. Woo (2014) considered that students with difficulty in interpersonal interaction would be hindered the personality development and emotion maturity. Niknejad and Rahbar (2015) indicated that ones being popular in peers acquired higher scores on ability self, psychological self, family self, social self, self-identification, self-satisfaction, self-action, and self-total score than those being alone; and, the difference was remarkable. It revealed the correlation between peer relationship and self-concept. In this case, the following hypothesis is proposed in this study.

H3: Self-concept presents notable correlations with peer relationship.

RESEARCH METHOD

Methodology Model

Goodness-of-fit in LISREL model could generally be tested with overall model fit (external quality of model) and internal quality of model. Regarding the test of overall model fit, the common indicators contain (1)"$\chi 2$ ratio" (Chi-Square ratio), standing for the gap between real theory model and expected value, which is better smaller than 3, (2)goodness of fit index (GFI) and adjusted goodness of fit index (AGFI), which appear better goodness-of-fit when being closer to 1, (3)root mean square residual (RMR) to reflect "mean of fit residual variance/covariance", which is better smaller than 0.05, and (4)incremental fit index (IFI), showing good model fit when being larger than 0.9.

LISREL is often applied as the assessment indicator of internal quality of model, including (1) SMC (square multiple correlation) of individual manifest variable, as R2 of manifest variable and latent variable, which is better

Table 1. Model analysis

	Evaluation Indicator	Judgment Standard	Result
Overall model fit	*p* -value	*p* -value > 0.05	0.000
	$\chi 2$/d.f.	< 3	1.323
	GFI	> 0.9	0.976
	AGFI	> 0.9	0.906
	CFI	> 0.9	0.951
	RMR	< 0.05 and lower than 0.025 good	0.011
	RMSEA	0.05~0.08 favorable < 0.05 good	0.016
	NFI	> 0.9	0.931
	IFI	> 0.9	0.924

Table 2. SMC of variable to dimensions

Art Education Therapy			
Curriculum Design	**Curriculum Content**	**Group Dynamics**	**Multiple Assessments**
0.68	0.71	0.73	0.78

larger than 0.5, (2) component reliability of latent variable (ρ), as Cronbach's α coefficient of the observation indicator of the latent variable, which is better larger than 0.6, and (3) average variance extracted of latent variable, which is calculated with the sum of manifest variables R2 of a latent variable divided by the number of manifest variables, revealing the percentage of latent variable being measured with manifest variable, which is better larger than 0.5.

Research Sample and Object

Quasi-experimental research is applied in this study. Total 98 university students in two classes of LuXun Academy of Fine Arts in Shenyang City, Liaoning Province, are selected as the research object for the 16-week (3hr per week for total 48 hours) experimental art education therapy teaching with information technology. The retrieved data are analyzed with SPSS, and Regression Analysis and Analysis of Variance are utilized for testing the hypotheses.

Reliability and Validity Test

Validity refers to a measurement scale being able to actually measure the degree what a researcher would like to measure. Common validity contains "content validity", which tends to the test of qualitative concepts, "criterion validity", which evaluates known external criterion and correlation coefficient in this test, and "construct validity", used for evaluating the consistency of a measurement to other observable variables. The questionnaire contents are based on past theories and designed to authentically express the essence of object and complete representativeness to ensure the content validity. Besides, the final commonality estimate in Factor Analysis is applied to test the construct validity of questions. The validity value appears in 0.7~0.9, showing the favorable validity of this questionnaire.

EMPIRICAL RESULT ANALYSIS

Model Fit Test

"Maximum Likelihood" (ML) is used in this study for the estimation, and the analysis result achieves the convergence. As shown in **Table 1**, the overall model fit indicators pass the test, thoroughly reflect the favorable external quality of model.

Path Relationship Test

In regard to the test of internal quality of model, SMC of manifest variables is larger than 0.5 (**Table 2** & **3**), revealing good measuring indicators of latent variables. Furthermore, latent variables of art education therapy, self-concept, and peer relationship show the component reliability higher than 0.6 and the average variance extracted of dimensions is larger than 0.5 (**Table 4**) that it conforms to requirement for the internal quality of model.

Table 3. SMC of variable to dimensions

Self-concept			Peer Relationship		
Body Image	**Social Self**	**Person Identity**	**Self-understanding**	**Social Skill**	**Support and Belonging**
0.72	0.77	0.81	0.76	0.80	0.83

Table 4. Component reliability and average variance extracted of variable

Item	Art Education Therapy	Self-concept	Peer Relationship
Component Reliability	**0.813**	**0.844**	**0.857**
average variance extracted	0.80	0.85	0.86

Table 5. Linear Structural Relations Model analysis result

Evaluation Item	Parameter/Evaluation Standard	Result	t
Internal fit	art education therapy → self-concept	0.846	18.67**
	art education therapy → peer relationship	0.831	26.46**
	self-concept → peer relationship	0.858	28.35**

Table 6. Hypothesis test

Research Hypothesis	Correlation	Empirical Result	p	Result
H1	+	0.846	0.00	Supported
H2	+	0.831	0.00	Supported
H3	+	0.858	0.00	Supported

Table 5 reveals positive and significant correlations between art education therapy and self-concept (0.846), art education therapy and peer relationship (0.831), and self-concept and peer relationship (0.858) that H1, 2 & 3 are supported. The hypothesis test results are shown in **Table 6**.

CONCLUSION

The research results reveal that school life presents important proportion on university students' self-concept development. Students are gradually separating from subjective stage and developing objective self-image in the interaction process with teachers, friends, and peers in the school life. Meanwhile, the self-value system is gradually formed along with the rapid development of emotion and intelligence. Apparently, the application of information technology to art education therapy stresses on the good interaction between teachers and peers as well as secure, acceptable, and inclusive classroom climate to help university students develop positive self-value systems as the factors in university students' self-concept growth. The application of information technology to art education therapy proves that art education therapy could enhance university students' positive changes in peer relationship. The creation space created by teachers is secure, acceptable, and empathic that students could really express the emotion and idea. Teachers extending such inclusive attitude to classroom management could establish good parent-teacher-student relationship, including providing parent-teacher and parent-child communication opportunities and shortening parent-teacher-student distance. Besides, it could change teachers' role from traditional authority and answer provider to listener of students' living events and secret sharer. It could create interaction space for students to induce students' autonomous interaction, change the after-school interaction mode, enhance the integration of sub-group in a class, and effectively assist students in developing harmonious sexual relationship and interaction to promote peer relationship.

SUGGESTION

According to the research results and findings, practical suggestions are further proposed.

1. Art education therapy teaching is a kind of respect and affirmation. Nevertheless, how can a teacher help some students who could not have the skills achieve the expected level? Painting ability is closely related to university students' development. In addition to making perfect with practice, students' physical and mental maturity and the cultural stimulation are the factors. In addition to well applying various multimedia exploration activities with information technology, increasing contact with students, and being familiar with materials, teachers could design suitable art education therapy courses by communicating with the tutors and parents and understanding students' background to enhance students' self-concept and peer relationship.
2. Art activity could promote university students' self-concept and self-confidence and the acquisition of achievement. Art media, art process, and completed works could provide students with growth

opportunities, self-concept, self-satisfaction, and value. For this reason, art education therapy could be regarded as each teacher's guidance competency. Although it is not necessary for each teacher presenting the ability to practice art education therapy, correct concepts could help students' growth. It is therefore suggested that education units could emphasize the study on art education therapy and broadly open the channels for relevant courses or seminars.

3. Teachers present distinct specialties. There are few teachers presenting completely mated professional background with art therapy field. Art teachers are therefore encouraged to cooperate with therapy teachers to really develop the interdisciplinary characteristics. What is more, domestic professional talents could be introduced. Although they do not have doctorate degree, the professional capability is affirmative; especially, they would actually help empower students.

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Students' Utilization of Distance Learning through an Interventional Online Module Based on Moore Transactional Distance Theory

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ABSTRACT

Introduction: Online learning platforms potentially increase student engagement and interactivity, thus contributing toward enhancing students' satisfaction with distance learning. The main aim of this research is to investigate the efficacy of an interventional online module based on Moore transactional distance theory on students' learning autonomy and satisfaction regarding the utilization of distance learning.

Materials and Methods: An experimental design was conducted with a stratified random sample of 100 students (50 control and 50 intervention) from the University College of Applied Sciences, Palestine. Three tools were applied in this study: the DELES instrument, which was given to the intervention group, another validated tool that was given to the control group and an achievement test that was introduced to both groups. The intervention included educational and training sessions that were given in the environment of online learning after the student's baseline assessment.

Results: It was noted that there was a significance difference in the domain of instructor support before and after the intervention within the intervention group. It was also observed that there was no significant difference (NSD) in the mean scores for students' collaboration and interaction, satisfaction and learning autonomy within the intervention group before and after the intervention. Moreover, there was NSD in mean scores for remembering, understanding or application among two groups (control and intervention) before and after the intervention, whereas it was a significant difference in the mean analysis score among the intervention and the control group before and after the intervention.

Keywords: distance learning, Moore theory, transnational distance theory, Moodle

INTRODUCTION

Many people have negative perceptions and conceptions about distance learning education, considering it to be poor in performance. Yet new tools and techniques such as distance learning, web-based courses, learning management systems (LMS) and Moodle are making significant contributions in the distance learning arena and increasing students' satisfaction (Ali, 2011). Distance learning is not a new concept, and nor is research on this topic (Means, Toyama, Murphy & Baki, 2013; Simonson, Schlosser & Orellana, 2011; Zhao, Lei, Yan, Lai & Tan, 2005). Although distance and online learners have faced many challenges historically, such as impersonal interactions and unsatisfying, (Lee, Srinivasan, Trail, Lewis & Lopez, 2011; Paechter, Maier & Macher, 2010; Song, Singleton, Hill & Koh, 2004; Vonderwell, 2003). Still the number of students signing up for distance learning courses has increased dramatically over the past thirty years. With the rapid expansion and increasing availability of material and communication technologies, distance learning courses have continued to improve, and new methods have been developed.

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Contribution of this paper to the literature

- Transactional distance theory of distance learning was the theoretical frame work for this study.
- An interventional module including both online and face to face courses were conducted.
- This research is the first to be conducted in the Gaza strip regarding distance learning.

Moreover, distance learning is not a new fact phenomenon, its popularity has increased the interest and visibility in distance learning as a new method of research and learning to enhance the audiences (Gasevic, Kovanovic, Joksimovic & Siemens, 2014). In addition, the line between distance education and traditional education has become blurred, as many establishments have incorporated blended learning into their programs and courses. Some on-campus classes, using a blended approach, also incorporate opportunities for online discussions so that student conversations can continue beyond the classroom (Jacobs, Renandya, & Power, 2016). Online learning platforms can potentially increase student engagement and interactivity, thus contributing toward enhancing students' satisfaction with distance learning (Garrison, 2011; Harasim, 2012). The issue to be explored here is the design and structure of online discussion, and attention also needs to be given to the course design and the management process of the course, and the construction of activities and organizational structures that lead to a proper environment for distance learning. Identifying the extent to which online interactions demonstrate meaningful student learning becomes crucial to understanding the learning potential that is afforded through such things as online discussion forums.

Online course design based on Moodle provides a variety of tools to students such as email (asynchronous), chat rooms (synchronous), discussion forums and course content spaces: these features offer students a range of interactive opportunities, including student-to-content, student-to-instructor interaction and student-to-student (Moore & Kearsley, 2005). As a learning platform, Moodle can enhance the learning environment (Stanley & Adam 2014). In addition, this platform has an extended range of criteria along with useful features, such as offering access to the web-based environment from any location, a day of 24 hours, a week of 7 days, so that student can get instructions, submit and compose their assignments, ask their instructors questions and discuss issues with their fellow students with the help of internet connections (Gartner, 2014). The purpose for this research was to highlight the connection between distance learning and students' achievement, along with their autonomy and satisfaction in the distance learning field. The research was conducted at the Applied Science University in Gaza Strip, Palestine.

Students' performance was considered as the dependent variable and tutorial meetings, assignments and face-to-face sessions were considered as independent variables. The researcher developed an internet course via the Moodle system based on the transactional distance theory of Moore. The target population for this research was ASU students studying Applied Teaching Systems, and the sample comprised 100 students from Applied Science University in Gaza. A self-managed questionnaire study was used for data collection through convenience sampling and non-probability sampling. The research supports the hypotheses that tutorial meetings and assignments have the strongest and most significant impact on students' performance.

BACKGROUND

Theoretical Framework

Moore's Transactional Distance theory considered as a theoretical framework to design this research. Moore (1983) developed this theory of distance learning programs to investigate two variables: students' autonomy and the distance between students and teachers (Hanson et al., 1997). Transitional Distance theory mainly describes the learner and the educator/teacher relationship. The transactional distance is essential, according to Moore's understanding, because the perception is grounded in distance learning within a social structure, not in its traditional form. The second element of Moore's theory involves the autonomy of the student, as the distance between him and his teacher means that the student must adopt responsibility for his own learning.

Moore (1997) summarized distance learning interaction by describing three forms of interaction:

i. Learner-content interaction: Students can get information from the course contents using this method. The contents may be in the form of text, video or audio, online communication, computer-aided programs or CD-ROM.

ii. Learner-learner interaction: This kind of interaction is used for the exchange of ideas and information about the course that arises among students in the absence or presence of the teacher. This kind of interaction may appear in the form of group discussion, group projects, etc. It can promote learning via sharing of knowledge and student collaboration.

iii. Learner-instructor interaction: This is related to the instructor and the learner communication. It may appear in the form of an instructor conveying information, inspiring the learner, or giving feedback. Additionally, it may incorporate the learner's interaction with the teacher by communicating or asking questions related to course exercises.

Moore's interaction theory has been adapted and extended. For example, Hillman, Willis and Gunawardena (1994) included learner-interface interaction "it is another form of interaction and an operating tools procedure to achieve a task". Sutton (2001), on the other hand, included indirect interaction: "Indirect interaction occurs when a certain learner supervises actively a certain interaction between other learners and the instructor or between another two learners". The adoption and extension of interaction theory emphasizes the influence and impact of Moore's work upon technology research in education with the growth of online learning.

The researcher believes that the key challenge for teachers in a distance learning is the process of applying the distance learning and its theoretical basis, as many are unsure about how to go through this process with confidence. A theoretical framework can be seen as a means to predict what to expect in distance learning under particular conditions and circumstances, thus providing enhanced practical application. Moore's position as a bigger in distance learning is clear, along with his contribution as the main founder of distance learning. Practitioners of educational technology in distance learning have access to important scholarly interaction. Moore's theories about distance learning and his contributions to scholarship and practice have influenced numerous instructive technologists in significant ways.

This study was set out to develop student satisfaction regarding distance learning courses in the Gaza strip, where there is a lack of researches has been focused in the area of distance learning, as this study is the first to be conducted in the Gaza higher education.

LITERATURE REVIEW

Discussing the studies conducted in distance learning field enrich this study's literature for many reasons. (1) Obtaining and knowing better perceptions on the history of distance learning. (2) To provide the criticisms needed for providing future studies, as the urgent necessity to have researches and practices for distance learning high quality.

Considerable amount of studies has clarified the strong connection between the student interaction, and their roles in enhancing achievements in distance learning e.g., Bryant & Bates (2015), Yang, Yu, Chen, and Huang (2014). Normally, interaction has three elements or forms: 1) learner-educator interaction; 2) learner-learner interaction; and 3) learner-content interaction. The interactions between learner-educator can be synchronous or asynchronous as viewed above, with the educator's delivering the knowledge, easing the learning process, question answering, and giving the needed feedback.

The research findings of Mahle (2011) recommended that the student satisfaction and interaction may have dependent relationship. Satisfaction happens when it is comprehended performance meets learners' expectations and considered a short-term attitude about the learning process. High education satisfaction researchers concentrate on the distribution and operational side of the learner's experience in the teaching process. The feedback of the learners can affect the course delivering and areas in which it might enhanced.

Results in the researchers conducted by Bordelon (2013) reported and concluded a positive relationship between both achievement and satisfaction. Bordelon indicated that reason behind such results, might be cultural differences in learners' satisfaction that indicates learning accession Zhu (2012). In addition, due to previous factors such as the service performance, universities performance, relationships and university standing. Although satisfaction was not related in an explicit way to the achievements of the learners, it is a statement of confidence in the system and the trust combined within, its importance cannot be overruled.

Ekwunife-Orakwue and Teng (2014) found that there was not such a noticeable distinctive comparison between online, blended and traditional environments. However, they recommend blended and online courses with few direct meetings, as this could benefit the student more than the archived lecturer.

MATERIALS AND METHODS

Study Design

This study adopted an experimental design. Two groups were made for participants, the first is a control group, it did not receive the intended interference, the 2nd is an intervention group, it received the proposed intervention, including the post and pre-Questionnaire and the post and pre-achievement test to triangulate the data.

Sample and Sampling

To eliminate the source of bias in treatment assignments, a stratified random sampling method was applied to recruit 100 students. The sample included students in the first and second year at the University College of Applied Sciences (UCAS) who were registered for the Educational Psychology course. Twenty-four (48.0%) of the students who joined the intervention group were male and 26 (52.0%) were female. The sample size was calculated using power-sample size software and in consultation with a statistician. The participants were selected from the Department of Education at UCAS because it is the biggest department in the college, with many students. Moreover, the Educational Psychology course is one of the compulsory courses listed in the Department of Education.

MOODLE's Importance

Moodle is a free web application, which helps both teachers and educators to create and develop online courses. As a learning platform, Moodle can enhance the learning environments Stanley (2014). In addition, this platform has an extended range of criteria along with great features Gartner (2012). Moodle can be utilized in many environments forms, as an open source, which helps developers to create and edit this environment based on their own needs and desires. Developers and users have the free choice to update, purchase tools, or determine how courses and websites should possess based on their desires.

Martin Dougiamas developed this system, and he managed to create a device with technological characteristics along with pedagogical satisfactory Moodle Partners (2016). Users and programmers working collaboratively within their special environments like Moodle has been elevated. Moodle's great achievement is because it allowed the viability and the ability to reach the system anywhere in the world, making the system as one of the most system used to manage courses at distance. Moodle has been translated into over 100 different languages and is accessible in many countries worldwide (Language packs – Moodle Docs). In addition, it has been used as a platform within an extended range of companies all around the world, in order to create online courses.

TOOLS AND DATA COLLECTION

A web-based measure, namely the "Distance Education Learning Environments Survey" (DELES: Walker & Fraser, 2005), has been selected for use in this research because it emphasizes the environment of students' learning perceptions to the elimination of technical issues, such as learning platforms or internet access, as found in other tools for examining distance learning environments.

Certain modifications were made to the DELES instrument and it was then validated again. The framework for this research is Moore's TDT. DELES was made to analyze the perceptions of students about their distance education social environment through six scales: students' authentic learning, consisting of five items; interaction and collaboration, containing six items; support of instructor, containing eight items; student autonomy, containing ten items; personal relevance, containing seven items; and active learning, containing five items. The original five-point scale (never, seldom, sometimes, often and always) was retained. The DELES tool was given to the experimental group, while another suitable validated tool that the researcher has developed was given to the control group: the DELES tool was not suitable for this group, since they were not receiving courses via distance/online learning.

Moreover, an achievement test was developed for this study by an expert in educational psychology. The achievement test was applied before and after the intervention: this test, which has previously been shown to be valid and reliable, was introduced to both groups at the same time. The achievement test was carried out to identify the extent of the study participants' actual response to the proposed intervention, thus providing support for the study results and demonstrating that the students within the intervention group achieved the same scores as those in the control group. The validated achievement test consisted of four domains, namely: 1) remembering, 2) understanding, 3) application, and 4) analysis. Each domain consisted of questions which reflect the nature and process of domain measurement, and this test had a total of forty questions.

INTERVENTION STRATEGY

Educational and training sessions were given in the online learning field after the baseline assessment of students. Two sessions were conducted face-to-face to introduce the students to distance learning and Moodle. The educational training sessions were given in class time during Educational Psychology classes twice a week, included information about video conferencing use and the importance of distance learning strategies. The lectures also included videos and materials that demonstrated appropriate ways of participation in online classes, creating successful student-student and student-lecturer dialogue.

Table 1. Baseline comparison of mean scores for student satisfaction, interaction and collaboration, instructor support and learning autonomy

Domain	Intervention Mean (SD)	Control Mean (SD)	*t* statistics (df)	*p* value*
Instructor support	1.91 (1.03)	2.11 (0.66)	1.149 (83.15)	0.254
Student satisfaction, Interaction and Collaboration	2.32 (0.87)	2.60 (0.55)	1.868 (82.87)	0.065
Learning autonomy	2.13 (0.95)	2.38 (0.68)	1.491 (88.89)	0.140

* Independent sample *t* test
SD = Standard Deviation
df = Degree of Freedom

Table 2. Comparison of student satisfaction, interaction and collaboration, instructor support and learning autonomy inside groups based on time (n=100)

Measurement level	Intervention Group (n = 50)			Control Group (n = 50)		
	MD (C.I. 95%)	*F* statistics (df)	*p*-Value*	MD (C.I. 95%)	*F* statistics (df)	*P* Value*
Instructor support						
PRE-POST intervention	-0.603 (-1.001, -0.205)	9.280 (1, 49)	0.004	0.183 (-0.203, 0.568)	0.905 (1, 49)	0.346
Learning autonomy PRE-POST intervention	0.056 (-0.243, 0.355)	0.143 (1, 49)	0.707	-0.090 (-.0311, 0.131)	0.672 (1, 49)	0.416
Student satisfaction PRE-POST intervention	0.007 (-0.124, 0.139)	0.013 (1, 49)	0.910	0.158 (0.003, 0.314)	4.171 (1, 49)	0.047

One-way ANOVA with Repeated Measurements was applied inside group analysis, subsequently Pairwise Comparison with confidence interval settings.
* Pairwise comparison with Bonferroni correction to correct the significance level.
MD = Mean Difference.
PRE = Baseline measures of mean variables
POST = Mean variables measurement after 6 months

df = Degree of Freedom
CI = Confidence Interval

The study was then carried out for eight weeks through a web-based course that was designed for this study using Moodle. The course was designed based on Moore's transactional distance theory. Most of the sessions lasted for approximately 45 minutes. Training sessions emphasized several issues, such as: i) introducing educational psychology, ii) educational psychology theories, iii) psychology in education, and iv). Exercises were also provided. After the completion of the education and training program, each student was given a written handbook, presentation handouts and a video CD and materials to help in absorbing the lectures information. In this study, the intervention program is an evidence-based approach regarding online learning in education.

RESULTS

Table 1 demonstrates that there are NSD in any of the domains (interaction and collaboration, support of instructor, student satisfaction and learning autonomy) between the control and the intervention group at baseline measurement ($p>0.050$).

The study results showed that the mean score for instructor support was lower at pre-intervention (1.91) than at post intervention (2.52). It was observed a significant difference in the mean score for instructor support inside the group intervention as revealed in **Table 2** (correction as per Huynh–Feldt, F= 9.280, $p< 0.05$). The post- and pre-intervention results show that the mean score for instructor support was lower at post-intervention (2.32) than at pre-intervention (2.31). It was also observed that there was NSD in the mean scores for student satisfaction, interaction and collaboration within the intervention group (correction as per Huynh–Feldt, F= 0.013, $p> 0.05$).

Moreover, the post- and pre-intervention findings recommended that the mean score for learning autonomy was lower at post-intervention (2.08) than at pre-intervention (2.13). It was observed that there was NSD in the mean score for learning autonomy within the group intervention (correction as per Huynh–Feldt, F= 0.143, $p> 0.05$: see **Table 2**).

Table 3. Mean difference in remembering, understanding, application and analysis before and after the intervention among the intervention and the control group: between-groups effect (n=100)

Comparison	MD (C.I 95%)	*F* statistics (df)	p-value
Control – Intervention Remembering	-4.120 (-4.420, -3.320)	0.046 (1)	0.831
Control – Intervention Understanding	-4.990 (-5.316, -4.664)	0.000 (1)	0.983
Control – Intervention Application	-1.200 (-1.375, -1.025)	0.023 (1)	.0880
Control – Intervention Analysis	-2.410 (-2.690, -2.130)	4.343 (1)	0.040

One-Way Repeated Measures ANOVA was applied within group analysis
MD = Mean Difference.Significance level was adjusted at 0.05 l (two-tailed)
df = Degree of Freedom

Regarding the achievement test, the results showed NSD in mean remembering, understanding, or application between two groups before and after the intervention ($p>0.05$), although it was a significant difference in the mean score for analysis of the two groups (control and intervention) before and after the intervention ($p<0.05$): see **Table 3**.

DISCUSSION

This study is the first of its kind to be conducted in Palestine. It utilized a randomized controlled design since it applied an interventional program and sought to identify the differences before and after this program via online methods. The study results displayed that there were no statistically significance differences within groups in the majority of study domains, such as student satisfaction, interaction and collaboration and learning autonomy. Our study results thus provide evidence that the distance educational method is effective in the education and learning system in terms of understanding, remembering and some of the processes required in the systematic stages of education, as there were no substantial differences within and between the two methods (online and face-to-face), which means that student in online courses showed a good result in conjunction with face to face group. This study results were found to be Consistent with study of Ekwunife-Orakwue and Teng (2014) where they explored that, no such difference between online and face to face courses, with few direct meetings, which leads to the importance of "blended learning courses, with more direct meetings. The results in **Table 3** show that the majority of comparative domains that have been used as parameters to differentiate between online and face-to-face methods are not different before and after the proposed intervention.

The current technology plays an indispensable part in giving a learning background that is close to a face-to-face class despite learners' physical separation from the instructor and other learners. Distance learning has become possible because of technology, and these results indicate that communication tools used in the distance learning situation connect both time and physical dimensions to close the students and faculty as a virtual group. The implication of technology enormously encourages and improves the communication not only between teachers and students but also among students. Consequently, the effective and efficient implication of technology in delivering Web-based courses is of critical importance for learning. It demonstrates that students want to use interaction tools to make their learning easier and more efficient and allow them to learn anywhere and at any time.

Instructors teaching via online methods should have the abilities and skills to adapt the basic and advanced requirements that they use during face-to-face methods. Moreover, instructor could help and support the students throughout the distance learning process. This comes in conjunction with Lewis (2011) and he described that for student satisfaction, learner-teacher interaction is a good predictor. As other research suggested that instructors integrate the communication with learners using learning platform and give support and feedback. The statistically significant difference presence within the intervention group for the domain of instructor support may be attributed to the nature of the intervention idea. The instructor might have found some barriers in dealing with students, and the students might also have encountered some barriers during communication with their instructor. Further, it is important not to forget that this intervention and this program were applied for the first time in Palestine, and specifically in the Gaza Strip: thus, it is normal for some initial technical and managerial problems to emerge in the implementation of the proposed idea.

In the present study, instructor support did not change before and after the intervention within or between the two groups. This issue is very important because the absence of instructor support would create substantial problems regarding distance education for the majority of students. Evidence for this is provided by Kirmizi (2014), who found a modest level of association between interaction and student collaboration, active learning, student autonomy, personal relevance, educator support and authentic learning.

Some previous studies have stated that distance education has several advantages, such as reducing travel costs and time, collaboration with and access to expert professionals expanding opportunities at a worldwide range, and a flexible approach that enables students to access courses and their contents at their convenience (Finch & Jacobs, 2012). Which is more needed in the Gaza strip, where there is a massive siege that restricts all aspects of daily life, including education and travel, this method would be greatly beneficial for students who do not have the ability to travel for education, especially in educational specialties that are not available in the Gaza Strip but are available on the other side of the same country (West Bank). This area has numerous important educational courses and programs that unfortunately cannot be reached due to the so-called Israeli checkpoints and barriers that have been imposed upon and between Palestinian areas, as well as the continuous closure of the Rafah border crossing, which is the only point at which the Gaza Strip is accessible to the outside world.

Our study results are consistent with previous results such as those of Bell and Fedeman (2013), who concluded that the broad range of different technological advancements utilized by universities during online courses can improve the communication not only between learners and instructors but also among learners. This was achieved in our study and has had a substantial benefit, in that the anonymous nature of the online environment is favorable to shy and anxious students who are reluctant to participate directly in classes, as it enables them to join online programs where they do not have to see each other physically.

The absence of statistically significant differences between the two considered groups after and before the interventional program grants this study a sense of Success. Its results provide huge support for distance learning and encourage its implications by universities in the Gaza Strip during the imposed siege, since some prior investigations have clarified the strong association between sense of community, social interaction and success in distance learning (see, for example, Bryant & Bates, 2015; Yang, Kinshuk, Yu, Chen, & Huang, 2014). Moreover, our results are consistent in some ways with those reported by Judrups (2015), who concluded that knowledge management and distance learning bring both disciplines closer and support integration. Model analysis assured several integration approaches.

Moreover, our study results support the claims that have been constructed in earlier literature and research regarding the application of distance learning theories in the design and instructions for distance learning. For example, Yu (2015) stated that students' satisfaction was positively associated with self-regulation, self-efficacy and interaction during distance education. Also, Choy and Quek (2016) reported an imperative direct association between continuous academic-related online performance, satisfaction and cognitive elements.

In Gaza Strip, there is only one culture: this may provide clarity and support for the positive results revealed by this study which was found to be in conjunction with Bordelon (2013) that reported a positive relationship between achievement and satisfaction and suggested that this might be due to cultural differences in learners' satisfaction. Furthermore, our study methods and materials have granted the learners a sense of support and met their expectations; this issue was considered pivotal in the study conducted by Mahle (2011), who suggested that the association between student satisfaction and interaction happens when perceived performance meets learners' expectations.

The results obtained in the achievement test as shown in **Table 4** reveal that there is NSD in mean scores in the majority of domains, such as remembering, understanding, and application, between the two groups before and after the intervention, whereas it is a significant difference in the mean analysis scores between the intervention and the control group before and after the intervention. The absence of significant differences provides strong support for the intervention, since the main aim of the achievement test was to support the study results in the three domains examined in **Table 3**. The results obtained in the achievement test reflect that students were satisfied during the distance education process and felt as comfortable as the control group, since there was NSD between the control and the intervention group in the three domains mentioned above. The significant difference in the domain of analysis between the control and the intervention group may be ascribed to the fact that some learning processes cannot be achieved via online methods or may need to be re-investigated and re-tested in future studies.

A limitation of this research is that the findings did not show higher results in student's satisfaction and learning autonomy in the distance learning group, as there was NSD between the two groups (distance learning and face to face group). It isn't acknowledged whether the transactional distance for online components of a program were seen due to the assigned discussion contents, the discussions design, the course design used through Moodle, "which is considered to be the first experiment in the Gaza strip", the teachers online skills, or if combining different factors to produce the resulting dissatisfaction.

Further research should be conducted in the strip, to enrich the distance learning experience to students, considering conduction a free workshop on distance learning for both students and instructors.

CONCLUSION

The distance education is a teaching technique which make the students and instructor separated physically or by time. Normally students use different type of materials, such as electronic media, references, books and CD-ROMs instead of face-to-face learning, these materials and contents are basically instructed by the technology.

In addition, they are also frequently designed for the ease of the online technology system. Further research should explore ways to improve and develop intellectual rigidity and encourage informed and individual perspectives and determine how to apply technology to involve learners in ongoing and multiple discussions in different online courses. Additional investigation is required to determine how group designs can influence the sense of community learning and social interaction in light of learning styles, skill levels, different personalities and group members. Earlier studies have focused primarily on postings by participants. Using the current technological developments, more research is required to explore different technological elements role in engaging more operative social interaction and fostering a sense of learning communities such as video or audio conferencing using Skype and Google Hangouts, virtual reality and social media network environments.

The researcher has applied the theories and strategies of distance learning to contribute the first distance learning research and endeavor in Palestine. This will aid higher education institutions to increase students' satisfaction with full online courses based on Moore's transactional distance learning and to measure students' autonomy and satisfaction through the Moodle system. Many issues need to be examined in the process of understanding the best practices to be applied to enhance distance teaching and learning.

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The Impact of Interaction between Timing of Feedback Provision in Distance E-Learning and Learning Styles on achieving Learning Outcomes among Arab Open University Students

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ABSTRACT

The present study aims to identify the impact of interaction between timing of providing feedback and technologies delivered in E-Learning environments (Immediate – Delayed) & interaction with learning style (Active – Reflective) on developing the design and production skills of educational e-blogging; and satisfaction with e-learning environment. The sample consisted of (67) students from the Arab Open University, Kingdom of Saudi Arabia, Dammam Branch. The participants were divided into four experimental groups according to the design Factorial (2 × 2): Group 1: (19) students with active learning style provided with immediate feedback; Group 2: (17) students with active learning style provided with delayed feedback; Group 3: (15) reflective students provided with immediate feedback; Group 4: (16) reflective students provided with delayed feedback. The tools include observation card, satisfaction scale with e-learning environment and learning style scale. The results showed statistically significant differences between the mean scores of the experimental groups, which received immediate feedback in acquiring the design and production skills of blogging and satisfaction with e-learning environment. The results also showed that students with active learning style were superior in their performance on each of the performance practical skills for the design and production of blogs and satisfaction with e-learning environment.

Keywords: learning style, e-learning platform, mobile learning (m- Learning), Imam Abdulrahman Bin Faisal University

INTRODUCTION

In the light of the rapid development of e-learning and distance education, a lot of universities across the world provide their courses and programs on the internet or in blended E-learning style. The number of students learning those courses around the world is in rapid increase, although there are different levels and types of E-learning. Most of studies confirmed that it's necessary to consider the quality of learning method and its effectiveness. The courses quality is an important key to achieve effective learning in e-learning environment (Xu, 2010).

The learner needs guidance and immediate feedback during and after the study, and the effectiveness of e-learning increases through providing an immediate feedback which provides the learner with a lot of experience and helps improve his/her cognitive skills. Feedbacks enable the learner to participate and lead an effective discussion with their teachers and colleges, without feedback styles the e-learning design will become just plans to broadcast specific contents (Afifi, 2014).

The effective feedback of the evaluated formation plays a basic role in motivating students properly in e-learning environment. Sorensen (2008) suggested to make the feedback a part and parcel of the design processes of e-learning and evaluation because it encourages students to participate and strengthen their independence. Previous studies confirmed that designing new perfect strategies to provide effective feedback of e-learning

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Contribution of this paper to the literature

- This study revealing the impact of interaction between timing feedback provision (immediate - delayed) and learning style (active - reflective). Students who received immediate feedback across M-learning environment techniques acquiring skills of the design of E-blogging and satisfaction about E-learning environment compared to the Students which received delayed feedback across learning management System (LMS).
- Active style students prefer learning through experimentation and team work, which made them achieve to better results in each of the practical performance of the design and production skills of e-blogging and satisfaction with e-learning environments, from those students who tends to abstract thinking, which Received delayed feedback type that provided to them across asynchronous blog in LMS.
- We believe the employing M-learning environments as effective tools for feedback provision as using smart personal cell phones to deliver feedbacks for students from a distance and fast reply to their tasks contribution in improving the quality of feedback and its impact on learning as well as achieving satisfaction through E-learning from a distance.

environment requires doing experimental research to specify which strategic factor of feedback agrees with learners and the necessary procedures for effective learning with feedback (Freney & Wood, 2008; Narciss, 2013; Narciss et al., 2014; Vandewaetere, Desmet, & Clarebout, 2011).

Evans and Waring (2004) found that students with specific learning styles may respond more to other different feedback types, or may prefer other feedback types which help them improve their acknowledgement (Evans & Waring, 2011).

The study attempt to benefit from employment of levels of timing feedback provision by presentation timing varieties in the e-learning course that presented to learners through different platforms (immediate across mobile learning "google+ platform", delayed across learning management system "Moodle") to determine which levels are more effective.

OBJECTIVES

Revealing the impact of interaction between timing feedback provision (immediate across mobile-learning environment "google+ platform" and delayed across learning management system "Moodle", which are more suitable for the two dimensions of learning styles (active - reflective) by its significant impact on acquiring the skills of designing E-blogging and satisfaction with E-learning environment.

SIGNIFICANCE

- Qualify the teachers who teach the courses electronically and the designer of learning environment with the best feedback design types and the appropriate time of its provision.
- Guide the students towards timing feedback provision which suitable to his learning style to contribute in raising his performance standard and achieve satisfaction with e-learning environment.
- Direct the E-learning designers concern to the necessity of providing different electronic feedback types in E-learning environment to confront the individual differences among learners.
- The study considered as a part of doing more interaction between treatment and preparations, since it aims to provide education agreed with personal abilities and characteristics.

QUESTIONS

1. What is the impact of different timing feedback provision (Immediate - delayed) on (A- acquisition of the design and production skills of E-blogging, and B- satisfaction with E-learning environment)?
2. What is the impact of learning styles difference (active - reflective) on (A- acquisition of the design and production skills of E-blogging, and B- satisfaction with E-learning environment)?
3. What is the impact of the interaction between timing feedback provision (immediate -delayed), and learning style (active – reflective) on (A- acquisition of the design and production skills of E-blogging, and B- satisfaction with E-learning environment)?

HYPOTHESES

1. There is a statistically significant difference at level (0.05) between the mean scores of the experimental group students in their performance on the scale estimate for practical performance of the design and production skills of E-blogging due to the different timing feedback provision (Immediate - delayed).
2. There is a statistically significant difference at level (0.05) between the mean scores of the student with active learning style and the reflective students in their performance on practical scale estimate of the design and production skills of E-blogging.
3. There is a statistically significant difference at level (0.05) between the mean scores of the experimental groups students in their practical performance for the production and design skills of E- blogs due to the impact of interaction between timing feedback provision (immediate - delayed) and learning style (active - reflective).
4. There is a statistically significant difference at level (0.05) between the mean scores of the experimental groups students in their performance on satisfaction scale with E-learning environment due to different timing feedback provision (immediate - delayed).
5. There is a statistically significant difference at level (0.05) between the mean scores of the experimental groups students with active learning style and the reflective students in their performance on satisfaction scale of E-learning environment.
6. There is a statistically significant difference at level (0.05) between the mean scores of the experimental groups students in their performance on satisfaction scale about E-learning environment due to the impact of interaction between timing feedback provision (Immediate - Delayed) and learning style (Active - Reflective).

LIMITATIONS

For the purpose of the current research is limited to:

- Arab Open University students associated with general Diploma program in education and the whole registered to study educational technology course (Ed, 433).
- Two types of timing feedback provision (immediate - delayed)
- Active Learning style versus the reflective according to Felder - Silverman learning styles model without other learning styles.

METHODOLOGY AND PROCEDURES

The author utilized the experimental method to study the impact of different timing feedback provision and its delivery techniques in different E-learning environment (immediate across techniques of M-learning environment "google+ platform", delayed across techniques of E-learning management system "Moodle") on each of: the design and production skills for E-blogging and satisfaction with E-learning environment; and interaction with learning style (active – reflective).

VARIABLES

*Independent variable***:** *feedback provision styles***:** (Immediate feedback across techniques of M-learning environment; and Delayed feedback across techniques of learning management system "Moodle".

Classified variable: the current research included classified variable which is the leaning style: Active style versus reflective style.

Dependent variables: (The design and production of skills E-blogging; and Satisfaction with E-learning environment.

THE EXPERIMENTAL DESIGN OF THE RESEARCH

The experimental design depends on the factorial design (2*2), which concerns with measuring the impact of two independent variables, and for each variable two levels at the same time (Khamis, 2013). Consequently, there are four experimental groups (**Figure 1**).

← Timing feedback provision and delivery techniques in two different distance E-learning environment →

Learning Style		Immediate using M-learning "google+ platform"	Delayed feedback using learning management system "Moodle"
↑	Active	Group (1); NO= 19 Active students provided by immediate feedback	Group (2); NO=17 Active students provided by delayed feedback
↓	Reflective	Group (3); NO= 15 Reflective students provided by immediate feedback	Group (4); NO= 16 Reflective students provided by delayed feedback

Figure 1. Experimental design research

SAMPLE

Arab Open University students of KSA Dammam branch, enrolled in Educational Technology course, 2nd semester of 2013 /2014. The sample consisted of (67) students with age average (27.03), standard deviation (3.56), classified of two experimental groups according to experimental design and research variables.

PROCEDURES

Prepare Measuring Tools

This study prepares the following measuring tools: Scale estimate, to observe the outputs of the students from E-blogging; satisfaction scale with the e-learning environment; learning style scale for Felder-Silverman Learning Styles Model (Felder & Silverman, 1988).

Scale estimate

Aims at measuring behavioral performance in designing and producing educational blogs skills, by using (blogger.com) one of management content style and specify the scale dimensions and items; backgrounds, theoretical attitudes, and literature reviews (Collison et al., 2006; Hsu, 2011, 2012), associated to E-blogs, were accessed, and get benefits to design observation card. This card enrolled 4 sub-skills, every skill covers a number of behavioral performance that students should carry out sequentially, and with the specific accuracy to get the behavioral performance accomplishment mark, these skills are:

- Designing the general shape for the blog (design the user interface) with (8) behavioral performances that can be observed.
- Designing (patterns, drawings, videos, and links) in educational blog, considering the technical measurements with (21) behavioral performances that can be observed.
- Accomplishing scientific standards of designing educational blog with (6) behavioral performances that can be observed.
- Accomplishing the activation of educational blog sides, with (5) behavioral performance that can be observed.

The observation card was showed to a group of information technology specialists to specify if it is appropriate for the purpose of the current research. Also, it applied to the survey sample from students learned this course without the main research sample, the observation card internal validity was checked by calculating correlation coefficient matrix between its dimensions and its total degree, the correlation coefficient values rang between (0.783-0.319) and the correlation coefficient previous values significance at level (0.01); demonstrate how far the internal consistency of the observation card construction. To measure the card reliability, the researcher observed the survey sample students' performance during carrying out the assigned tasks of design and produce the educational blog by using the required tools; then another college from educational technology section who has experience in designing educational blog, and production tools, observed the same sample performance and measured the reliability through Cooper equation to measure similarities and differences rate among the observers, the values agreement rates ranged between(90.1% : 83.6%) this indicates the validity of observation card, hence the observation card became ready in its final shape, abstract (4) and valid to apply the current research purpose.

Table 1. Correlation coefficient matrix for e-learning environment satisfaction dimension scale

Scale cores	System using facility	System function	Interactions (teachers and students support)	Feedback provision synchronizing	General satisfaction	Total degree of scale
System using facility satisfaction	-					
System functions satisfaction	0.451**	-				
Interaction satisfaction (teacher, students support)	0.615**	0.574**	-			
Feedback provision synchronizing	0.487**	0.694**	0.629**	-		
Learning environment satisfaction	0.549**	0.652**	0.694**	0.718**	-	
Total degree of scale	0.627**	0.735**	0.720**	0.763**	0.778**	-

* Values significance on level (0.01)

E-learning environment satisfaction scale

It aims at measuring students' E-learning environment satisfaction. To specify the scale dimensions, terms, backgrounds, theoretical attitudes, and various concepts in E-leaning field. E-learning environment satisfaction, were accessed, and to benefit from some literature reviews included used tools and measurements (Chang, 2011; Harrati, Bouchrika, Tari, & Ladjailia, 2016; Harvey, Parahoo, & Santally, 2017; Raspopovic & Jankulovic, 2017; Violante & Vezzetti, 2015; Virtanen et al., 2017; Wu, Tennyson & Hsia, 2010). This scale enrolled 36 phrases presented in 5 dimensions: The facility of using the systems, System functions, Interactions, Feedback provision synchronism, Overall satisfaction with learning environment.

The e-learning environment satisfaction scale was viewed to the judges of the tools to specify its appropriateness for the purpose of the recent research, its formatting accuracy, and it's covering to the representative cores, and doing the required editions in the light of the judge's views. Also the researcher applied the scale on the survey sample from students who learned the course with this method in the first semester without the research sample, then the researcher calculates the scale internal validity of correlation coefficient matrix between its phrases degree and the total degree points, the correlation coefficient values ranged between (0.396 – 0.837) this indicates the phrases correlation range of the scale with each other and with the total degree, the previous correlation coefficient values is significance level at (0.01) and prove the scale internal constructive consistency range also calculating the correlations coefficient between the scale dimension and its total mark to reveal the internal consistency components, viewed in **Table 1**.

The previous values of correlation coefficient is an indicator for scale cores and phrases validity of measuring the e-learning environment satisfaction to measure the scale reliability, the researcher evaluated the survey sample students on this scale then counted Cronbach's Alpha correlation value that reached (0.718), this value is appropriate for the recent research, hence the scale satisfaction became in its final shape, abstract (5), valid to apply on the recent study.

Learning style scale

The researcher used "Felder & Silverman Learning Styles Model" which developed before (Felder & Silverman, 1988). The scale consists of 44 dimensions: 11 items for every dimension. The students classified at this scale through bipolar four dimensions; (active – reflective), (sensual – initiative), (visual – oral), (sequential – comprehensive). There are two choices for each item (A- B), the first choice represents the first trend, and the second choice represents the second trend of the dimension; and give mark (1) with (A) choice and (-1) with (B) choice. Every dimension measured by eleven items putted in the questionnaire periodically, and the questionnaire gives four marks (it has no Fullmark) through it, we could distribute students according to the used learning style and students classified according to this model as following: If the student got a mark between (3 & -3), it means he does not prefer any of two dimensions style; If the student got a mark between (-5 & -7) or (+5 & +7), it means he prefer any of two dimensions style with moderate degree; If the student got a mark between (-9 & -11) or (+9 & +11), it means that he prefer any of two dimensions strongly.

Numerous studies and researches are done to verify the validity and reliability of learning style indicator questionnaire on different samples from university students, and from many cultures and various societies. So the questionnaire was translated to six languages, and the results of those studies showed approximate values for the

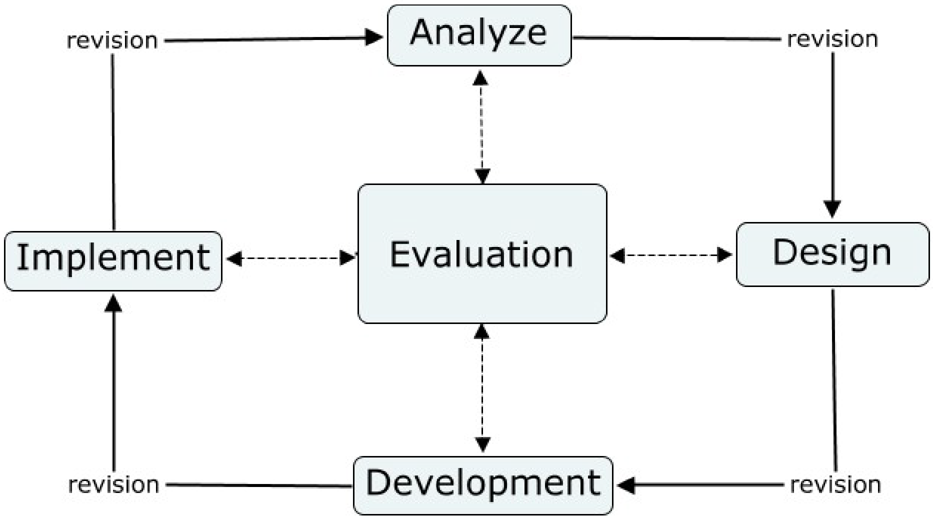

Figure 2. ADDIE instructional design model

validity and reliability of the model from a study to another (Filippidis & Tsoukalas, 2009). In Zywno (2003), the sample consisted of (577) university students; the results verified that the scale has a high reliability degree using the reapplying method whereas Pearson correlation coefficient values are between (0.507 & 0.683) and all of them were significant statistically. Litzinger et al. (2007) investigated the reliability and validity of learning style scale where the internal consistency coefficient for the four learning styles items enrolled by the scale was extracted.

Also, at Arab environment, Abu-Hashem (2010) measured the construct validity for Felder and Silverman learning style model on a sample of university students, and translated the questionnaire to Arabic language. Abu-Auad and Noafl (2012) measured the validity and reliability significant for Felder- Solomn scale of learning style, while it was translated to Arabic at Jordanian environment on a survey sampling from Jordanian university students amount to (455) students, and it found that the scale has internal consistency coefficient for the four measurement items.

Design and Development of the Research Experimental Treatment

The author designed the experimental treatment and developed it by using (ADDIE) model. The ADDIE model is a systematic instructional design model consisting of five phases: (1) Analysis, (2) Design, (3) Development, (4) Implementation, and (5) Evaluation (Branch, 2009). It can be illustrated as shown in **Figure 2**.

A. ***Analysis phase***: the following steps were taken:

- *Determining the learners and their educational need*: the learners are from the associated students to the general diploma program in Education Arab open university, KSA branch , which presents the academic programs to the students according to blended E-learning model, hence the students study 75% from learning time from a distance, and attending the remain learning time every 15 days face to face with the course teacher, and the description of the course requires student acquisition for practical skills and drills in course field through distance e-learning systems; Therefore, they are in a bad need to provide feedback for the students at appropriate time , and be constructive, motivating students, and communicate directly with evaluation standers and learning results for the required practical tasks.
- *Determine the general aim:* the experimental treatment aims to recognize the appropriate time to provide feedback (immediate – delayed), and the most appropriate technique to deliver to the learner in distance E-learning environment, and that came from its function impact on acquiring the design skills of educational E-blogs and satisfaction achievement with E-learning environment.
- *Determine learning content*: the content of technology learning course enrolled the following objectives: (1) The smart board and its uses in teaching; (2) Web techniques; (3) Broad cast techniques; (4) mobile – learning techniques and the design and production skills of educational E-blogging using the necessary software considered as the practical application of this course.

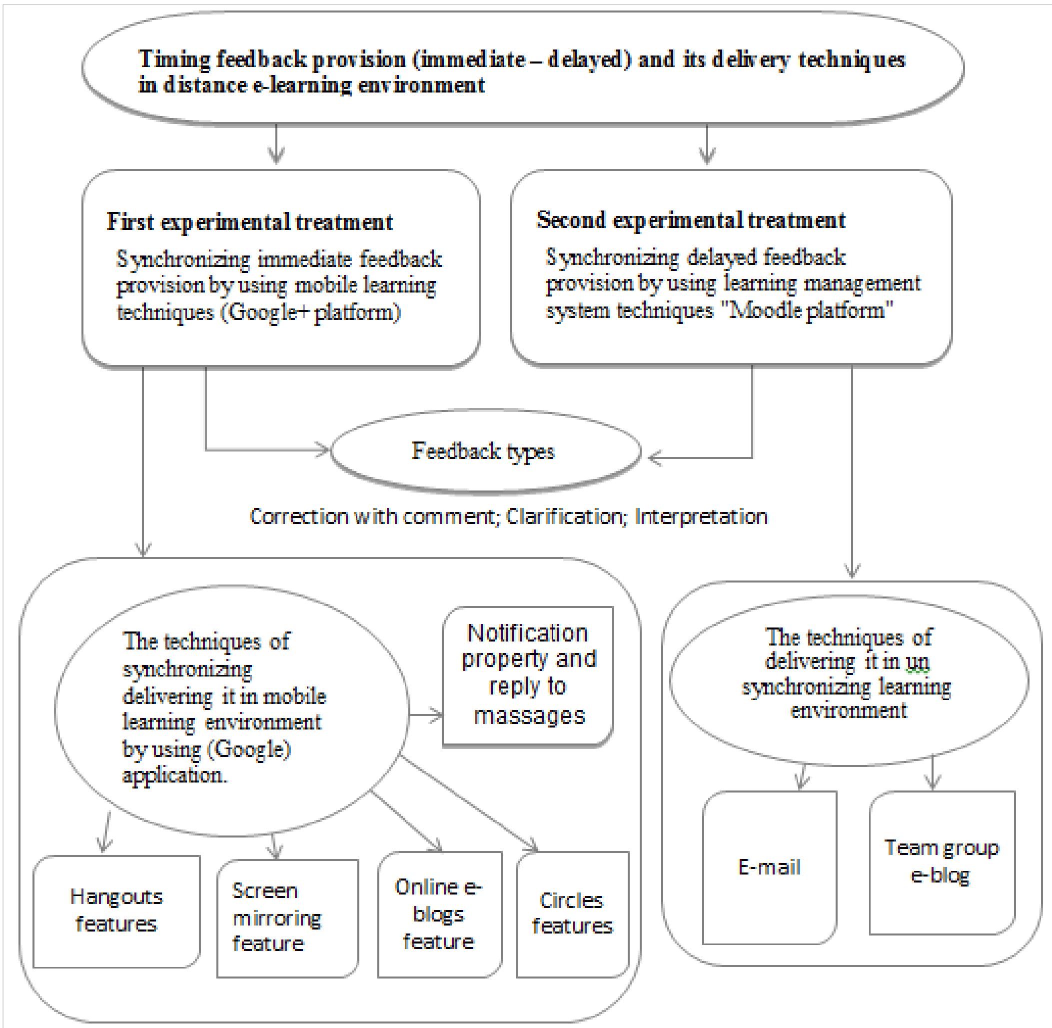

Figure 3. Design of the research experimental treatment

B. Design phase:

In this phase, the content of e- learning designed, developed, and put on the management system, this content uses distance-learning style for both the experimental groups and the only difference between them is presented in feedback provision time and its presentation method (immediate -delayed). Figure 3 explain that.

- **The first experimental treatment:**

It was developed to provide immediate feedback by using mobile-learning techniques (Google+) as the following; regardless learning styles, the learner receives in this experimental group an immediate feedback for educational tasks inquiries, performed; immediately after finishing performing every stage in it or performing it totally, this would be (individual or team work), (written text or auditory voice call/ note or multimedia SMS) of (Google+) tools through the experimental treatment across tablets , and smart phones , that enabled experimental groups learner the interactions between them and the course teacher and among themselves shortly at the moment of inquiry or the moment of delivering the task, to check it and give the appropriate feedback through employing the following tools:

- *Circles establishment:* This tool enable the course teacher to collect students in one group connected through a relationship of studying the course, accomplish the tasks, and the assigned practical tasks from a distance, this enable them to share the relative content and common interests with the teacher of the course in addition to solve the problem that may encounter them
- *Hangouts:* Making a video call: this tool (hangouts) enabled learners of experimental group to speak live (individual- team work) through voice and live image or sharing files, and editing them together or mirroring their (mobile screen or computers screen) with the course teacher or with their colleges , also this feature enable to collect group of friends have problem in performing a task or a procedure of the required

task procedures to make a conference call through video chat face to face with text, images, to find solution for the problems that may confront them during performing the practical task.

- *E-blogs:* (Google+) e-blogs consider places in which individuals get together, talking about common interests; this feature enabled the course teacher and learners from a distance to perform an immediate participation, and to see others' participation, also to see their works, and the accomplished steps they take in carrying out their assigned practical tasks. It can be a participation theory text or images or videos or links or sites bookmarks, also the participation can be whether individual with person or through team work for a circle of the other established circles, hence the content will appear in their e-blog page.
- *SMS short massages:* This tool enabled learners of experimental group to receive immediate notifications for every action, course teacher makes or any other learner in the same circle, also every comment added, and every conversation done, all across SMS. in this experimental treatment those used tools helped the course teacher to provide immediate feedback for every activity or task performed instantly, and just after finishing the task, all viewed immediately on the course teacher cell phone , and the other learners of this course, who participate in the same circle, hence all links of blogs, produced by the learner, are in one circle, just when the learner add any edition in his blog, this edition appears directly to all other learners who are participating in this circle, and of course also for the course teacher, who by his turn give immediate feedback . also screen mirroring enabled the course teacher to follow the learner during his work on the blog in every step he takes from a distance, the course teacher can see it, and add immediate postscripts, this allow the course teacher to provide the immediate feedback on the tasks inquiries for every learner alone in personal or for a group of learners together.

- **The second experimental treatment:**

It was developed to provide delayed feedback by using learning management system techniques "Moodle". Regardless of learning style, the learner received in this experimental group "delayed feedback" which presented after learner response for learning task for a period of time which may take from an hour to 48 hours from sending the inquiry; that may be individual or teamwork ; (verbal written style) through employing learning management system tools that available to him across electronic gates of Arab open university, and that allows the students to study their courses from a distance by electronic method; the following tools are used in this experimental treatment which provide by the used learning management system:

- *The E-mail of learning management system*: to provide the learner with feedback after finishing any stage of E-blogs designing stages, or for whom have inquiry around the design and production steps for the required task.
- *Cooperative blogs for learning management system*: through learning management system a blog was established, so the students could discuss the problems they faced in studying the course or during fulfillment the required tasks and assignments, and the course teacher respond on it. This tool is used to provide (written) feedback to respond on the student inquiries and (delayed) whereas the course teacher log in to respond on the existed inquiries in the blog.

C. *Development phase*:

At the development phase, Researcher created and compiled the content assets described in the design phase. Create storyboards, Test material correction and procedures It. then reviews and revises the project according to the feedback.

D. *Application phase*:

The accomplishment of the study experimental treatments took ten academic learning weeks of the second semester, year 2013 – 2014; started from the second week of teaching and ended at the twelve week of teaching according to the timeline of teaching the course from a distance; hence the following are the procedures steps to accomplish experimental treatments of the study:

The Arab open university external students of educational general diploma program, studied the distance technology learning course by using the blended E-learning system through a period of time reached to 16 educational weeks, and through this period there are (5) tabled meetings face to face with the teacher of the course in the classroom.

- The student receives in his first face to face meeting: the course teaching book, time line for studying the course, and gets on the rest of learning activities with the course teacher across learning management system "Moodle" which available through university website gate.
- The course teacher in his first meeting face to face reviewed with the students the electronic content of the teaching course. It is about electronically views for the lectures using "power point views, PDF files" to be studied individually through learning management system.

Table 2. The arithmetical means and standard deviation of distance applying grade for e-learning environment satisfaction scale and observation card for both of feedback types and learning styles

Feedback provision timing	Learning Style	No	Scale estimate skills		e-learning environment satisfaction	
			Mean	SD	Mean	SD
"immediate" through m-learning environment by using (Google+) platform	Active	19	112.26	4.44	164.63	8.59
	Reflective	15	96.87	7.99	150.40	7.79
	Total	34	105.47	9.91	158.35	10.83
"delayed" through learning management system (Moodle) platform	Active	17	93.18	6.83	118.88	9.31
	Reflective	16	88.50	15.85	111.50	13.36
	Total	33	90.91	12.13	115.30	11.87

- As a part of final evaluation for the educational technology course, required from distance learning student: distance practical drill on one of E-content management programs for the purpose of designing and producing educational e-blogs.
- Determine the activity (task): the students carry out the practical assignments and the required tasks which represented in designing educational blog in his specialization field and producing it using one of E-content management programs necessary to it.
- The experimental group students who received "immediate feedback" and their amount is 34 students, are asked to make a new account and participating in the course circle across M-learning platform which using (Google+), and that for immediate communication, and receiving feedback from the course teacher about their inquiries, and following them in their assignments accomplishing steps, while the experimental group students who received (delayed feedback) to communicate with the course teacher through the blog and university mail for university learning management system "Moodle".
- After learners finishing the specific period to deliver their assignments and projects they load it electronically for the teacher to evaluate it and monitoring grades.

E. Evaluation phase:

After finishing the experimental treatment accomplishment of the research, the following measurement tools are applied: "observation card, E-learning environment satisfaction scale, learning styles scale"; the posttest applied on the sample of the study; to confirm the impact of different timing feedback provision and its delivery techniques indifferent e-learning environment (immediate – delayed) on each of, the design and production skills of educational E-blogs and satisfaction with learners learning style.

DISCUSSION AND INTERPRETATION

Descriptive Statistics of the Research Results

The statistics treatment has been done for the points of post- applying results of the experimental groups' performance on every observation card for educational blog design skills, and satisfaction scale measurement of e-learning environment for both of the two feedbacks with its two styles of learning and types, the result as **Table 2** illustrate.

The previous **Table 2** demonstrates the rise of students' mean scores of the experimental group who delivered immediate feedback across m-learning environment in their performance of e-learning blog design and production skills and e-learning environment satisfaction.

Also the table illustrates the rise of active students' mean scores whether those who delivered (immediate or delayed) feedback compared to reflective students in their performance of e-learning blogs design and production skills and e-learning environment satisfaction.

Results Associated to Research Hypotheses Validity Test

For the statistical analysis of the results, ANOVA Two-way analysis of variance and Descriptive statistics are utilized.

The impact of feedback (immediate across "Google+" - delayed across "Moodle") on acquiring e-learning blogs design skills

The first hypotheses of the research associated to the impact of feedback provision timing in distance e-learning various environment, regardless the following learning style on what precedes; "There is a significant statistical

Table 3. The results of two ways variable analysis of feedback provision timing (immediate across m-learning environment techniques: delayed across learning management system techniques), impact on e-learning blogs design and production

Variable source	Sum of squares	df	Means of Squares	"F" value	Significance Indicator
Among groups	5718.14	3	1906.01	20.77	0.000
Timing feedback provision	3132.25	1	3132.25	34.14	0.000
Learning style	1674.50	1	1674.50	18.25	0.000
Time of feedback * learning style	477.59	1	477.59	5.21	0.026
Error	5779.59	63	91.744		
Total	658892.0	67			

difference at level (0.05) between the mean scores of the experimental group students in their performance on the scale estimate for practical performance of the design and production of skills of E-blogging due to the different timing feedback provision (Immediate - delayed)" to test the validity of this hypotheses, the researcher used two ways variable analysis style for post-applying means of practical observation card for e-learning blogs design and production skills. The result as **Table 3** illustrates.

Table 3 demonstrates that there is significance statistics differences between experimental groups averages which received immediate feedback across m-learning environment techniques and those who received delayed feedback across learning management system techniques. That is why there is a basic impact of feedback provision timing in various e-learning environment; and to investigate the direction of differences and in favor of which group will be;

Scheffe's test was applied, and the results revealed statistics significance differences on significance level (0.01); and it was in favor of the experimental group who delivered immediate feedback across m-learning environment, also the arithmetic means of immediate feedback across m-learning environment was (105.47) with standard deviation equal (9.91) in confrontation with arithmetic means (90.91) with standard deviation equal(12.13) of those students who delivered delayed feedback across learning management system techniques, hence the first hypotheses of the research hypothesis was accepted.

Results of basic impact for (active- reflective) learning style on acquiring skills of design and producing e-blogs

The second hypotheses which associated to the impact of learning style -regardless timing of feedback provision-; states the following: "There is a significant statistical difference at level (0.05) between the mean scores of the student with active Learning style and the reflective students in their performance in practical scale estimate of the design and production Skills of E-blogging". To confirm the validity of this hypotheses go back to the previous **Tables 2** & **3** where the results demonstrate the value of (F) reached about (18.25) at significance indicator reached (0.01) ; this assure that there is a basic impact of learning style in students' mean scores in their practical performance on observation card practical performance for the skills of designing and producing e-blogs; which was in favor of the experimental group of active learning style who obtained the maximum Arithmetic's means that reached (102.72) compared to the Experimental group of reflective learning , as their arithmetic's means reached a value (92.86) that's why regardless. Feedback provision synchronizing type, practical active students obtained the highest score of E-learning blogging production and design by using required software, than reflective students that's why the second hypotheses of the research hypothesis was accepted.

Results of the basic impact of interaction between timing feedback provision (immediate - delayed) and learning style (active – reflective) on the design skills acquisition of educational e-blogs

The third hypothesis of the research hypotheses, which specialized with the effectiveness of interaction between the two types of timing feedback provision and between the two types of learning styles, states the following: "There is a significant statistical difference at level (0.05) between the mean scores of the of the experimental groups students in their practical performance for the production and design skills for the E- blogs returns to the impact of interaction between timing feedback provision (immediate - delayed) and learning style (active - reflective)".

To confirm the validity of this hypothesis should returns to the previous **Tables 2**, **3**, where the results clarify that (F) value that calculated for the impact of interaction between timing feedback provision and learning style reached to (5.21) at significant indicator (0.026) which less than (0.05), and that mean there is impact of interaction between timing feedback types and the learning style that used on students marks on their practical performance observation card for the design and production skills of e-blogs. To know the differences directions they returns to

Table 4. The results of bipolar variance analysis for the impact of timing feedback provision (immediate – delayed) on satisfaction scale of e-learning environment

Variable source	Sum of squares	df	Means of Squares	"F" value	Significance Indicator
Among groups	5718.14	3	1106.90	111.61	0.000
Timing feedback provision	3132.25	1	29779.06	300.47	0.000
Learning style	1674.50	1	1941.48	19.59	0.000
Time of feedback * learning style	477.59	1	194.96	1.96	0.166
Error	5779.59	63	99.11		
Total	658892.0	67			

"Scheffe" Test, and with reviewing the previous **Table 2** the following is illustrates: the rise of the mean scores of the active students with immediate feedback types across mobile-learning environment which its value reached to (112.26) with standard deviation (4.44), while the mean scores of the reflective students with immediate feedback type reached to (69.87) with standard deviation (7.99). Also the previous **Table 2** reveals that the experimental group with active practical learning style got mean scores (93.18) with standard deviation (6.83) higher than experimental group with reflective learning (88.50) with standard deviation (15.85) and that in delayed feedback type. All that prove there is impact of interaction between timing feedback provision (immediate – delayed) in both two different environments of e-learning and learning style (active – reflective) on the acquisition of the design and production skills of educational e-blogs, and this interaction is in favor of the experimental group students with active learning style and who received immediate feedback through mobile e-learning environment; due to that the third hypothesis of the research was accepted.

Results of the basic impact for timing feedback provision (immediate – delayed) on satisfaction with e-learning environment

The fourth hypothesis which associated with the impact of timing feedback provision from distance e-learning different environments - regardless the learning style – states the following: "There is a significant statistical difference at level (0.05) between the mean scores of the experimental groups students in their performance on satisfaction scale about E-learning environment returns to different timing feedback provision (immediate - delayed)".To test the validity of the hypothesis, the researcher used bipolar variance analysis style for the post applying scores of statistical scale about e-learning environment, the results viewed as **Table 4** illustrated.

Table 4 illustrate a significant statistical different between the mean scores of the experimental group that received immediate feedback through techniques of mobile e-learning environments. The other group that received delayed feedback through techniques of e-learning management system, that means there is a basic impact of timing feedback synchronization of feedback in different e-learning environments in the experimental groups' performance on satisfaction scale with e-learning environment and to investigate the difference direction and in favor of which group; "scheffe" Test is used and the results revealed that there is a significant statistical difference at significance level reached (0.01) it was in favor of the experimental group which received immediate feedback through mobile e-learning environment (google+) that got arithmetic means reached to (157.5) versus the experimental group that received delayed feedback "moodle" and got in its performance on the scale with arithmetic mean reached (115.19), so the validity of the fourth hypothesis from research hypotheses was accepted.

Basic impact results for learning style (active – reflective) on satisfaction with e-learning environment

The fifth hypothesis of the research hypotheses associated to the impact of learning style states on the following: "There is a significant statistical difference at level (0.05) between the mean scores of the experimental groups students with active learning style and the reflective students in their performance on satisfaction scale of E-learning environment". To confirm the validity of this hypothesis we return to **Tables 2** & **4** where illustrated from the results that (F) value reached (19.59) at significant indicator reached (0.01) which means that there is a basic impact of learning style on students' performance marks on satisfaction scale about e-learning environment in favor of the experimental group with the highest average, they are active learning style students which their arithmetic mean in performance on satisfaction scale about e-learning environment reached the value (141.76) comparing with the reflective experimental group students, which their arithmetic mean in performance reached the value (130.95). So the fifth hypothesis from research hypotheses was accepted.

Impact results on interaction between two types of feedback provision (immediate – delayed) and learning style (active – reflective) on satisfaction with e-learning environment

The sixth hypothesis of the research hypotheses that associated with the impact of interaction between the two used types of feedback, and the two used learning styles, states the following: "There is a significant statistical difference at level (0.05) between the mean scores of the of the experimental groups students in their performance on satisfaction scale about E-learning environment returns to the impact of interaction between timing feedback provision (Immediate - Delayed) and learning style (Active - Reflective)". To confirm the validity of the hypothesis should back to the two previous **Tables 2**, **4**, where the results illustrate that (F) calculated value for the impact of interaction between timing feedback provision and learning styles reached (1.976) at significant indicator reached (0.166) and it is lower than table value; that means there is no impact of interaction between timing feedback provision and the used learning style on the students' performance scores on satisfaction scale with e-learning environment. Hence the sixth hypothesis of the research hypotheses was declined.

The Interpretation of Research Result

The test result validity of the research hypothesis illustration as the following:

Results associated to the impact of feedback provision timing (immediate across mobile – learning management system techniques) on acquiring skills of E-blogs design and production, and satisfaction with e-learning environment

The results of the recent research referred to the differences of statistics significance between means scores of experimental groups who received immediate feedback in acquiring skills of producing and designing e-blogging and e-learning environment satisfaction. Due to the basic impact of feedback provision time (immediate across Mobile learning environment techniques - delayed across learning management system techniques) that's why the results were in favor of Experimental group (1 & 3) that received immediate feedback across M-learning environment techniques compared to the Experimental group (4 & 2) which received delayed feedback across learning management techniques. This result can be illustrated as the following:

The employment of Experimental treatment of synchronizing connecting tools across tablets or across (Google +) application, smart phones to present the immediate feedbacks , provided the student in this experimental groups with the interactions between student and the course teacher immediately and the moment of the inquiry, or the moment of delivering the task (sharing the blog link) to see it and receive the suitable feedback, immediately just after finishing any step or task of the practical tasks necessary to produce the required educational activity of designing and producing the E-blogging for their specialty field by using blogger services, at the same time without delay according to their actual needs. Besides the actual existence group students at the same time and at any place through their mobiles , helped them to exchange ideas through direct text message and conversation, voice calls and to solve the problem that confront them during designing and producing the educational tasks, students complete and follow their discussion at the same time with the course teacher across conference call (hangout) increased their ability to concentrate and follow and then accomplish their practical tasks. screen mirroring task also enabled the course teacher to follow the student and watch learner during working on the E-blogging in every step he makes from a distance and to give immediate post scripts of works, also enable the course teacher to deliver immediate feedback for the tasks and inquiries for every student alone in personal, or to a group of learner together in group, also blogger allowed the course teacher and distance learner to participate immediately (text – images – video clips and sites links) and see other's participants, work, and every step accomplished in implying their assigned practical tasks . also replying to notification across SMS feature enabled experimental group learners to receive immediate notifications for every participation by the teacher course or other learners at the course circle, also every comment added, Or conversation or a call made all through SMS, M- learning platform used in experimental group, distinguished with saving dialogue text discussion for all notices provided by the course teacher for learners during the stages of the designing and producing the E-learning task, so enabling all to review the feedback content at any moment, also the facility of practicing learning activity with smart phones, tablets reduced the required time for the course teacher to provide the learners of experimental group according to this type with fast and accurate postscripts (Taylor, Schugar, & Penny, 2014).

We can say: the tools and features distinguish this experiential treatment helped to deliver immediate feedback, for every task or activity done by the learner or just after the learner edit his blog or finish making any step of the learning task, viewed at once on the course teacher phone and other learners of this course and participating at the same circle phones and then the teacher does his turn in providing immediate feedback which make learners of the experimental groups achieve results more positive in acquiring skills of the design and production of E-blog and due to the immediate feedback was always fast and at the appropriate time and aims at developing students work papers, and helped the learners to carry out his task to the fullest, motivating and illustrated whatever the learner does. That's why the experimental groups students who received immediate feedback get more satisfied with E-learning environment than those who received delayed feedback within 48 hours, after asking for it across email or unsynchronized discussion forum through learning management system platform. This result agrees with other previous literature reviews' results, thus Xu study (2010) clarified that most students of this study sample (96%) percentage confirmed that immediate feedback delivered by their course teacher across tablets or lab-tops was too useful to understand the content and improve their self-motivation for learning, and provided them with interactions and participation with the teacher for the discussion performed online. Also this studies (Nortcliffe & Middleton, 2011) agree with "Nortcliffe" that revealed that using smart phones was more appropriate than any other various technique, helped the teacher to manage his time and Exceptional effort associated to submitting postscripts and put marks on students works and tasks, as a result, the study sample revealed that the students excited with a good motivate experience of using their personal smart phones to receive feedback and replies to the tasks which contribute in improving the quality of feedback and its impact on learning, Also those studies agree with Hwang and Chang (2011).

Studies results which revealed that formative Evaluation entrance based on M-learning environmental was very helpful and useful to improve their academic achievement and better their educational achievement, and develop their attitudes toward learning. Also those studies agree with Huang and his colleges students (2008) that revealed that M-learning systems facilitate synchronizing learning through enabling students receive lessons probably and effectively through various and wide groups of tools by using wireless devices, finally also agree with Chen and his colleges studies (Chen, Chang, & Wang, 2008).

That revealed that mobile phones immediate calling features affected learning process and interactions among students received materials and browsing functions in cell phone, enabled the users to receive information data in the appropriate time. The recent current study results with a conclusion of previous literature reviews shown above, clarify that M-learning environment is an effective tool of immediate feedback provision, and it has the ability to enhance academic achievement and improve students' learning outcomes and achieving environment satisfaction. These results are consistent with the results of previous studies (DeLucenay, Conn, & Corigliano, 2017; Lefevre, & Cox, 2017).

Results related to the impact of two learning styles (active – reflective) on each of acquiring the design and production skills of e-blogging and satisfaction with e-learning environment

The results illustrate that there is a significant statistical difference at level (0.01) between the mean scores of active learning style students and the reflective students in their performance on practical performance observation card for the design and production of e-blogging and satisfaction with e-learning environment; the researcher explain that by the following:

Active style students prefer learning through experimentation and team work, and they tend to obtain and understand the information through doing applicable process, and through teamwork, and that agree with the used experimental treatment type. Where the activity exercise of practical learning by designing and producing the e-blogging and team work learning, where the actual presence for the students at the same time, anywhere, anytime, and across their mobile devices or across other wireless devices, which help them to exchange ideas and immediate conversations whether text or voiced for solving problems that encountered them during the design and production process of educational task. The students completing their conversation and all of them are following it at the same time through communication device (hangouts). Moreover, their employment to the blogs which enabled them to do immediate participation and seeing the others participations and their projects and the accomplished tasks in fulfillment their practical tasks which assigned to them. Hence, we could say that there is harmony between the introduced experimental treatment style and the learning style for these experimental groups; the condition that made them achieve to better results in each of the practical performance of the design and production skills of e-blogging and satisfaction with e-learning environments, from those students who tends to abstract thinking, and prefer thinking quietly first, also they prefer individual word which agreed with delayed feedback type that provided to them across asynchronous blog in learning management system.

This result agreed with various studies results which confirm the interactions between the teacher of the course and the students, and among students themselves, were important to the learning process. Also the interaction at appropriate time between the teacher and the learner was definite in strengthen/ reinforcement student learning, and the immediate and quick feedback from the teacher at appropriate time are essential key to achieve learners satisfaction about e-learning environment (Harrati et al., 2016; Harvey et al., 2017; Raspopovic & Jankulovic, 2017; Violante & Vezzetti, 2015; Virtanen et al., 2017; Wu et al., 2010).

The results associated to the impact of interaction between timing feedback provision (immediate – delayed), and the two learning styles (active – reflective) on each of the design and production acquiring skills of e-blogging and satisfaction with e-learning environment

The results of the research indicates that there is a significant statistical difference at level (0.05) between the mean scores of the students sample of the research in their performance on practical performance observation card for the design and production skills of e-blogging, due to the impact of interaction between timing feedback provision (immediate across techniques of mobile e-learning environment –delayed across techniques of e-learning management system "Moodle") and learning style (active – reflective) which confirm the impact of interaction between timing feedback provision (immediate – delayed) and learning style (active – reflective) on acquiring the design and production skills of e-blogging, this result may explained as the characteristics of active style students agreed with immediate feedback provision across mobile e-learning environment. They prefer the active learning, and prefer learning in groups and in a team work, that allowed by the experimental treatment by providing synchronous communicated environment across mobile devices, and receiving immediate feedback which helped them to exchange ideas or immediate text conversations or the voiced one, to solve the problem that encounter them during the designing of educational task and producing it. So the students could acquire the design and production skills of e-blogs effectively.

While the results indicates that there in not a significant statistical difference at level (0.05) between the mean scores of the students sample of the research in their performance in satisfaction scale with e-learning environment returns to the impact of interaction between timing feedback provision (immediate – delayed) and learning style (active – reflective); that means there is no impact of interaction between timing feedback provision and the used learning style on students' scores in their performance on satisfaction scale with e-learning environment.

We could explain this result as regardless the learning style, the first and third experimental groups which received immediate feedback through techniques of mobile learning environment supplied approximated results and high satisfaction degrees about immediate feedback type and its facility receive across wireless communication techniques, which led to no existence of impact for the interaction between timing feedback and learning style on satisfaction scale of e-learning environment compared with the second and fourth experimental groups which received delayed feedback across learning management system "Moodle".

STUDY RECOMMENDATIONS AND PROPOSALS

In the light of the results that the recent research and previous literature reviews pointed to (DeLucenay et al., 2017; Harrati et al., 2016; Harvey et al., 2017; Lefevre & Cox, 2017; Raspopovic & Jankulovic, 2017; Violante & Vezzetti, 2015; Virtanen et al., 2017), and research's projects included in the folds, the researcher presented some recommendations and educational applications to benefit from it as a practical applications when designing E-learning contents as the following:

(1) Direct active students to synchronizing e-learning type, to achieve the maximum benefit from receiving immediate feedback during their studying to e-courses.

(2) Employing M-learning environments because it saves effective tools for feedback provision as using smart personal cell phones to deliver feedbacks for students from a distance and fast reply to their tasks contribution in improving the quality of feedback and its impact on learning as well as achieving satisfaction through E-learning from a distance.

(3) M-learning system should be employed to facilitate synchronizing learning as receiving learning subject and data transfer, browsing functions, SMS in cell phones help users to reach to feedback information at the appropriate time.

(4) The necessity of holding training courses for teaching staff members, and E-course designers to train them on the various strategies of perfect and effective feedback provision in E-learning environments from a distance as training them on provision methods with wireless synchronizing communication techniques, especially if we considered that feedback provision should be fast and immediate and at the appropriate time and more personalized for the learner.

The study proposed doing more researches to compare the impact of the different types of feedback contents and its receiving methods on improving some of learning outcomes for learners, of which:

(1) Doing a study to reveal distance significance of feedback (specify the mistake and correct it give the correct answer) (giving deeply detailed information or fast and brief information) on learning outcomes for learners.

(2) The impact of interactions between the feedback provision (individual - teamwork) specialty and learning style (active - reflective) in synchronizing E-learning environment on learning outcomes for learners.

(3) The impact of interactions between feedback types (brief text-detailed multimedia) in synchronizing e-learning environment and learning style (visual- verbal style) on the outcomes of the learners through learning process.

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Use of Blackboard Learning Management System: An Empirical Study of Staff Behavior at a South African University

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ABSTRACT

This study explores the use of a Learning management system (LMS), Blackboard, among academics at a South African university of technology. Based on the literature and the Unified Theory of Acceptance and Use of Technology (UTAUT) model, four constructs which influence academics' usage and behavioural intention to adopt LMS were considered: performance expectancy, effort expectancy, facilitating conditions, and social influence. Data was collected from 100 academics through a survey questionnaire, and correlations and regression was used to analyse the relationships. The results indicate that, facilitating conditions is the most influential factor explaining the usage of, and intention to use LMS among both users and non-users, while the set of variables, performance expectancy, effort expectancy, social influence, and facilitating conditions were not able to predict a significant amount of variance in intention to use LMS. Implications for practice are presented.

Keywords: blackboard, facilitating conditions, performance expectancy, UTAUT, staff

INTRODUCTION

The past twenty years have seen increasingly rapid advances in the field of technology enhanced education and e-learning initiatives. Students' preference for new media which includes various web applications that use the Internet as a platform (Montrieux, Vanderlinde, Schellens, & De Marez, 2015), indicates their inclination towards learning that may take place in an "anytime/anyplace world, that is not constrained by time or place". Furthermore, students (usually under 25 years old) of today are referred to as digital natives – these digital natives are inclined to interactive learning approaches which involve the use of group discussions, case studies, field studies, and simulations among others (Sarkar, Ford, & Manzo, 2017). However, institutions of higher learning have traditionally lectured face-to-face classes by making use of printed textbooks and many continue to do so. There appears to be a misalliance between how teaching takes place in some higher education institutions and what the digital natives expect the learning process to be. While the institutions are focusing on the process of educating, digital natives are more concerned with the outcomes of education (Montrieux et al., 2015). Academic staff at higher educational institutions need to change their approach to teaching in order to keep abreast with the technologically savvy students they serve. Many higher educational institutions have and continue to invest in online learning technologies to meet this expectation.

At a time when almost all universities are moving towards e-learning and making extensive use of information and communications technology (ICT) in teaching and learning, the University of Technology under study seems to be lagging behind. With huge student enrolments and associated large classes, access to education is still problematic for many students, despite the university's investment in a Learning Management System (LMS) such as Blackboard. Many students do not have access to computers and more specifically access to the internet at home, but these are available on the university campus. However, recently, more and more students are acquiring smart phones that are connected to the Internet (Sang, Chang, & Liu, 2016). Despite the availability of the LMS, Blackboard, which has been in place at the institution for a considerable period of time – many staff have not used the system. For the purposes of this study, 'staff' denotes academic staff.

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Contribution of this paper to the literature

- The results of this study point to the need for strong support systems for academic staff at HEIs to adopt LMS for effective teaching and learning.
- This study provides strong empirical confirmation that performance expectancy has a direct impact on behavioural intention to use a LMS.
- Allocating more time for technology enhanced teaching in the teaching workload of staff is just as important as having the infrastructure in place to influence behavioural intention and usage of the system.

With such a huge investment in time and money on acquiring and installing the LMS, Blackboard, it has become necessary to understand how and to what extent these technologies are being used, and to determine the perceptions of staff on the use of Blackboard. To this end, the study aims to investigate the perceptions of staff towards the use of Blackboard in teaching and learning and subsequently to understand the reasons for the slow adoption of Blackboard by staff. In order to determine the perceptions of staff, the research was guided by the following research questions:

1. What are the perceptions of staff on the use of Blackboard?
2. To what extent does performance expectancy, effort expectancy, social influence and facilitating conditions influence academics to use Blackboard?

In the next section an overview of the literature related to LMS and staff perceptions are explained, followed by a description of the methodology used. Thereafter the analysis is presented followed by a discussion and implications for practice.

LITERATURE REVIEW

Online Learning

In the last decade, the trend in education has been a move towards online instruction and "blended" instruction which replaces components of face-to-face instruction. Poon (2013) considers blended learning to be the combination of online and face-to-face learning. Blended instruction is often designed with the use of a learning management system to facilitate teaching and learning (Govender & Mkhize, 2015).

In the late 1990s, a significant transition in e-learning emerged as a result of the introduction of Learning Management Systems (LMSs). Among the popular examples of learning management systems are Blackboard, Moodle, and WebCT which are designed to facilitate web based learning (Kulshrestha & Kant, 2013). A learning management system (LMS) is a web enabled software platform designed to ensure efficient management and delivery of learning materials to students (Govender & Govender, 2012). Communication tools that a LMS provides enable easy interactions between lecturer and student and among students. LMSs enable various assessments such as the online quizzes to give instantaneous feedback thus providing a rich learning environment. (Govender & Govender, 2012). Learning management systems use the internet as its platform so as to enable students to access the resources anywhere and at any-time thus overcoming location and time boundaries. A LMS offers much more than simply facilitating access to resources, it enables interactive learning anytime and wherever the student chooses. Therefore, it is not surprising that learning management systems are at the forefront of e-learning initiatives in many Higher Education institutions (Heirdsfield, 2011). Furthermore, Kushrestha and Kant (2013) established that the use of a LMS can be tailored according to the students' specific learning styles and that e-learning is "culture - independent" (p 1164).

Despite the popularity of online learning globally, Nielsen (2013) argues that some limitations are characteristic of online learning, namely: the dropout rate of online learners is higher than that of a traditional class, online learners feel isolated and overwhelmed in pursuing online courses, inadequate development of problem solving skills, and reduced student interaction. In spite of the key advantage highlighted in Kushrestha and Kant's study, they also determined some inhibiters in the deployment of LMS – the availability of infrastructure, power and access to computers. As an unintentional compromise, many institutions are using blended learning – incorporating both online learning as well as traditional classroom learning – to overcome some of the limitations of exclusive online learning. As a result a richer learning environment is created than either an online or traditional class can achieve alone (Harding, Kaczynski, & Wood 2012). Blended learning in many institutions is facilitated by the use of a learning management system that not only serves as a repository for online resources, but adds a virtual dimension to traditional campus based studies (Heirdsfield 2011).

In the past the creation of an online learning environment meant that the instructor would have to create a web site and have an in depth understanding of various web technologies and programming skills. However, with the advent of a learning management system this skill is no longer required and makes the task of creating online learning environments simpler.

Use of Learning Management Systems

Learning management systems have impacted education to such an extent that the gap between distance education and campus based education has narrowed significantly. Previously, distance education students felt isolated and alone in pursuing their studies but this has changed with the advent of the LMS which provides many tools as well as virtual classrooms that students can explore and thus be in contact with the lecturer as well as other students (Heirdsfield 2011).

While many universities worldwide have adopted the use of a learning management system as a means of implementing online or blended learning, this adoption is at the organisational level, and not necessarily at the level of individual staff members.

Al-Busaidi and Al-Shihi (2010) add that the success of a learning management system at any institution first starts with the acceptance of this technology by instructors and this in turn will promote students' use of the LMS in class. In a very recent study on LMSs among academic staff, Govender and Govender (2014) affirmed that the successful implementation and adoption of an LMS begins with the academic staff embracing the use of the LMS first.

According to research done by Waycott et al. (2010), staff at higher education institutions felt that there are a number of benefits in using technology in teaching, namely: better communication, efficiency in facilitation of lectures, immediacy of access to information, convenient access to resources, and sustained student engagement. However, despite the many benefits highlighted, Salajan, Schönwetter, and Cleghorn (2010) revealed a number of challenges in using ICT in higher education: an increase in staff workload, usability / technical issues, the loss of face to face interaction, students' unprofessional use of communication tools and institutions' focus on technology rather than on pedagogy.

Additionally, staff felt that the use of technology in their classes not only increased their workload, but also gave students the impression that they are always available to answer questions. Other challenges were concerned with usability and technical issues which include the difficulty in navigation when using certain tools of the educational program. Interestingly, Waycott et al. (2010) found that staff were concerned about losing face-to-face interaction with their students when using technologies in communicating with them, yet the key benefit of using the technology is the range of communication tools available to facilitate communication among students and lecturers. In spite of this benefit, Waycott et al. (2010) observed that students did not only make less use of these tools, but made inappropriate comments on the discussion forums – totally unrelated to the subject at hand. They further emphasized that the decision to implement technology at institutions is driven by the competitive pressure among institutions in the use of technology rather than the inherent pedagogy that can be harnessed.

An understanding of the barriers to the adoption of a learning management system is just as important as the influencers – these barriers can be turned into a motivator in the adoption of an LMS.

The lack of release time for staff to prepare learning material and maintain the online resources is seen as an impediment to the adoption of e-learning (Anderson, 2012).

In his review of technology integration, Anderson (2012) indicated that staff incompetency is a major factor as to why staff choose not to integrate technology into their teaching. His study showed that only 10 percent of staff felt comfortable with incorporating technology into their teaching.

Another recent study conducted by Qamhieh, Benkraouda, and Amrane (2013) using Blackboard in an introductory physics course at UAEU, has shown that not only did the interactions between students and instructors improve and thereby improved students' attitude towards physics, but also online assessment improved physics learning. Blackboard assisted overall in teaching the course. Blackboard was found to be an effective learning management system by both students and instructors.

In his analysis of staff use of LMS, Heirdsfield (2011) claimed that the interactive features of Blackboard enhanced the learning experience, however, staff viewed face-to-face interactions in class as the most valuable learning experience. In a study investigating the acceptance of LMS, Maina and Nzuki (2015) found that performance expectancy, enabling infrastructures, support for training and ease of use influenced the acceptance of E- learning Management Systems in higher education in Kenya.

Van der Merwe (2011) in his research on online learning performance using microeconomics students at a university in Durban, South Africa, found that performance is significantly associated with the length of time a student spends in the online classroom in addition to the marks he obtains for the online formative assessments. This finding affirms a study conducted by Nyabana (2016) who reported improved performance of students who frequently interacted with Blackboard.

In trying to understand the perceptions of staff at a University in New Zealand towards the use of Blackboard, Missula (2008) found that the level of usefulness influences how often staff use Blackboard and how effectively lecturers use course tools on Blackboard. Furthermore, the study revealed that IT experience of staff does not influence the usage of Blackboard. However in a similar study conducted by Katunzi (2011) at a University in Finland it was found that IT experience did influence the usage of Blackboard.

Much research points to the enhancement of teaching and learning using Blackboard. However, the research findings emerged from different institutions using subjects from different cultures and computer backgrounds – different from the students and staff at the university under study. Therefore, it would be useful to determine the perceptions of staff towards the use of a LMS such as Blackboard in order to understand their behaviour in adopting Blackboard.

The next section describes the framework used to analyse the data.

THEORETICAL FRAMEWORK

The Unified Theory of Acceptance and Use of Technology (UTAUT) model was chosen for this study, since UTAUT explained approximately 70 percent of variance in behavioural intention to use technology in an organizational context and about 50 percent of variance in the use of technology (Venkatesh et al. 2003).

The UTAUT model developed by Venkatesh et al. (2003) as presented in **Figure 1**, explains the users intentions to use an information system and subsequent usage behaviour. UTAUT encompasses the eight previous models of IT usage behaviour, including an additional construct called Facilitating Conditions to predict Behavioural Intention to overcome the limitation of the TAM model. The theory states that four constructs are direct determinants of user acceptance and usage behaviour when using an information system. As can be seen in **Figure 1**, the four constructs are: Performance expectancy, Effort expectancy, Social influence, and Facilitating conditions.

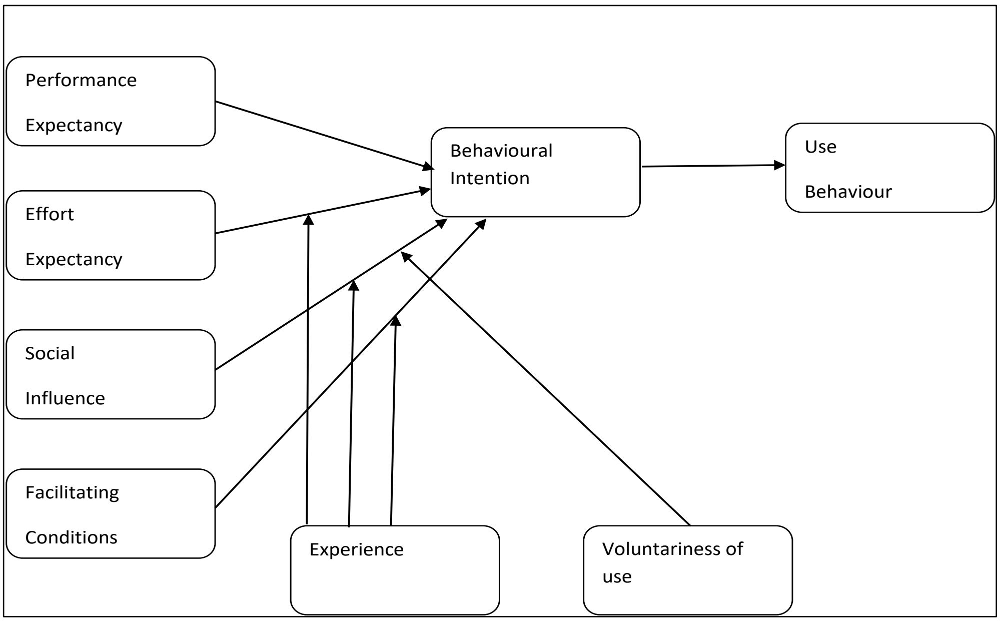

Figure 1. UTAUT model adapted from Venkatesh *et al.* (2003)

Performance expectancy is defined as the degree to which one believes that using the information system will assist one in doing one's job.

Effort expectancy is defined as the degree of ease associated with the use of the system.

Social influence is defined as the degree to which an individual perceives that important others believe he or she should use the new system.

Facilitating conditions are defined as the degree to which an individual believes that an organisational and technical infrastructure exists to support the use of the system (Venkatesh et al., 2003).

According to Venkatesh et al. (2003) gender, age, experience and voluntariness of use are postulated to moderate the influence of the four key constructs on usage intention and behaviour. For example, theory suggests that women tend to be more sensitive to others' opinions and therefore, find the social influence construct to be

Table 1. Constructs and Their Measurement Items for Staff

Construct	***Measurement item***
Performance Expectancy (PE)	PE1- Blackboard enables me to improve the effectiveness of my lecturing
	PE2- I can achieve more tasks quickly by using Blackboard
	PE3 - Blackboard supports the pedagogical principles in my lecturing
Effort Expectancy (EE)	EE1- I find Blackboard easy to use. EE2 – It is easy upload all the relevant material
Facilitating Conditions (FC)	FC 1- Management has supported my use of Blackboard.
	FC 2- I have received training on the use of Blackboard.
	FC 3- I have all the necessary resources to use Blackboard.
	FC 4- The IT infrastructure supports my usage of Blackboard.
	FC 5- I can call upon the assistance of a person or group at my campus if I am having difficulty using Blackboard.
Social Influence (SI)	SI 1- People who are important to me think I should use Blackboard. SI2 – My colleagues use Blackboard
Behavioural Intention (BI)	BI1 - I may use Blackboard BI2 – I intend using Blackboard BI3- I will continue to use Blackboard

more salient when forming an intention to use new technology and this effect decreases with experience (Venkatesh et al., 2003).

The UTAUT model was used in a study by Katunzi (2011) on the adoption of e-learning technologies at a University. The aim of the study was to understand the factors that influence teachers' adoption of a learning management system. The four key constructs from the UTAUT model were used to investigate how well the set of constructs is able to predict the intention to use the LMS. In this study, an additional construct of trust was added to the framework. Perceived usefulness, facilitating conditions and a user's gained experience were found to highly influence a teacher's decision to adopt an LMS. Perceived ease of use, social influence and trust were found to have little impact on whether a teacher adopts an LMS (Katunzi, 2011). The construct trust was not included in the current study due to the fact that Blackboard has not fully been adopted and no courses at the university are being offered fully online. In a more recent study, Govender and Govender (2014) revealed that the four constructs from the UTAUT model are correlated with the intention to use the LMS at different levels of significance. However, unlike the study by Katunzi (2011) the construct facilitating conditions showed weak correlations with the intention to use the LMS.

The two main objectives of the current research are to identify factors that positively influence the intention to use Blackboard and to likewise identify factors that inhibit the use of the LMS Blackboard. In identifying these factors the key constructs from the UTAUT model were used since the four key constructs are direct determinants of the intention to use or not to use the specified innovation. For the purposes of this study, facilitating conditions is associated with the intention to use Blackboard as proposed in **Figure 1** because of the limited use of Blackboard LMS in the institution.

In the current study, age, gender and voluntariness of use were not considered, since the number of male, and female respondents were equivalent, and the results showed similar statistics regarding those who used and those who did not use Blackboard. Similarly, the majority of respondents fell in the age category between 35 and 60 years; hence gender and age were not considered in the model as indicated in **Figure 1**.

METHODOLOGY

Research Design

The research approach adopted in this study was primarily quantitative in nature, which was found to be most effective in gathering data from the staff. The main research question was to determine how well the set of constructs (shown in **Table 1**) is able to predict behavioural intention and subsequent usage of Blackboard. The research questions were answered by using items of measurement for each of the constructs, PE, EE, SI and FC. A self-administered questionnaire was used for the collection of data.

Population

The target population for this study was permanent academic staff from the five faculties of the university. A total of 420 lecturers were surveyed. In order to accomplish the main objective of the study, respondents should be computer proficient and have Internet access. This criteria allowed one to gain an informed perspective of the participants' perceptions of intention to use or their usage of the LMS. All academic staff members (that is the population) are considered to be at least competent users of ICT and have access to the Internet. Hence, the selected sample was therefore deemed useful for the study.

Sampling and Size of Sample

In this study, the researcher attempted to obtain responses from all lecturers from the various faculties. A sample size of 196 was drawn from the population, which is considered representative of the population according to Sekaran and Bougie (2013). In other words, a sample sizes of greater than 30 but less than 500 are appropriate for most research in order to obtain a level of confidence and precision of our findings for the particular population. However, 100 lecturers responded and completed the online questionnaire, yielding a response rate of 51percent.

Data Collection

The questionnaire was designed and pre-tested with five academic staff members at this institution, before being distributed to all academic staff.

The questionnaires consisted of 5 sections which captured background information (demographical data), perceptions of staff, computer proficiency, their use of course tools and general questions on LMSs. Additionally, an open-ended question was included at the end to invite comments, in general, that might not have been captured in the other sections of the questionnaire.

Staff perceptions towards the usage of Blackboard are elicited via the items of measurement for each of the constructs shown in **Table 1**. The objective of these statements is to determine the perceptions of those staff members that are using Blackboard in their teaching. This section contained eight questions. The four key constructs from the research model was used to draw up the questions for this section. For each of the questions, five-point Likert scales ranging from "Strongly Agree" to "Strongly Disagree" was used to rate their attitude towards the use of Learning management systems.

Validity and Reliability

All of the themes (sub-sections) have values that exceed the acceptable standard. The overall reliability (0.963) exceeds the recommended value of 0.70 (Sekaran, 2010). This indicates a high (overall) degree of acceptable, consistent scoring for the research.

Data Analysis

Descriptive and inferential analysis was carried out using the Statistical Package for Social Sciences (SPSS). Multiple regression analysis was performed to predict the dependent variable, intention to use or adopt Blackboard.

ANALYSIS

The analysis of users of Blackboard is presented first, followed by the analysis of non-users of Blackboard. **Table 2** indicates the demographical information of all the participants in the study.

Table 2. Profile of Participants

		Do you use Blackboard?				
		Yes		No		Total per category
		Count	Percent (%)	Count	Percent (%)	
Gender	Male	8	42.1	41	50.6	49
	Female	11	57.9	40	49.4	51
	Total	*19*	*100*	*81*	*100*	*100*
Age group	18 – 24	1	5.3	1	1.2	2
	25 – 34	1	5.3	5	6.2	6
	35 – 60	16	84.2	66	81.5	82
	Above 60	1	5.3	9	11.1	10
	Total	*19*	*100*	*81*	*100*	*100*
Level	Junior Lecturer	2	10.53	0	0	2
	Lecturer	13	68.42	51	69	64
	Senior Lecturer	3	15.8	20	27	23
	Professor / Associate Professor	1	5.3	3	4	4
	missing					7
Lecturing Experience	0 – 5	4	21.05	8	9.9	12
	6 – 10	4	21.05	13	16	17
	11 – 15	4	21.05	18	22.2	22
	16 – 20	3	15.8	19	23.5	22
	> 20	4	21.05	23	28.4	27
	Total	*19*	*100*	*81*	*100*	*100*
Perceived Computer proficiency	I never used a computer	0	0.0	1	1.3	1
	I am a beginner	0	0.0	0	0	0
	Fairly knowledgeable	12	63.2	47	58	59
	Very Proficient	7	36.8	33	40.7	40

Overall 81.5 percent (n=81 as indicated in **Table 2**) of all the participants between the ages 35 and 60 years do not use Blackboard. This statistic could be attributed to the fact that they are much older than the digital natives and may not be receptive to embracing new technology easily. A noteworthy aspect that may be observed from **Table 2** is that those who are lecturing for longer than 10 years do not use Blackboard. It is likely that staff are resistant to change despite the fact that most academics (99%) have self-assessed themselves to be fairly knowledgeable and proficient in computing.

The analysis for the users and non-users are presented in sections "Analysis of Blackboard Users" and "Analysis of Non-Users of Blackboard" respectively.

Analysis of Blackboard Users

In this section, the responses of the users of Blackboard are analysed. The Likert scale of "strongly disagree" and "disagree" were collapsed to show a single category of "Disagree". A similar procedure was followed for the levels of agreement (positive statements) to create brevity in the explanations. The results are first presented using percentages for the variables that constitute each section. Results are then further analysed according to the importance of the statements.

The influence of Performance Expectancy (PE) on staff use of blackboard

Approximately 80 percent of the respondents that use Blackboard for their teaching feel that Blackboard will enable them to improve the effectiveness of their lecturing. However 10.5 percent feel that Blackboard will not improve the effectiveness of their lecturing despite their use of Blackboard for teaching. Yet, about 79 percent of the respondents that use Blackboard feel that they can achieve more tasks quickly by using Blackboard.

Approximately 68.4 percent of the respondents feel that Blackboard supports the pedagogical principles in their lecturing. It is likely why they are using it to teach.

A significant number of respondents are in agreement with the statements, "Blackboard enables me to improve the effectiveness of my lecturing", "I can achieve more tasks quickly by using Blackboard", and "Blackboard supports the pedagogical principles in my lecturing".

These statements are designed to measure performance expectancy. These statements are indicative of lecturers' willingness to use Blackboard in their teaching.

According to the UTAUT model the gender and age variables moderates the impact of performance expectancy on behavioural intention, however, in this study, no significant relationship was found to exist between the items of measurement for performance expectancy and gender and age.

The influence of Effort Expectancy (EE) on staff use of blackboard

The one sample t-test for the construct effort expectancy resulted in t(18) = 1.379, p= 0.185. The observed difference between the agreement and disagreement for this construct was not significant. **Table 3** provides the frequencies of the Likert scale item for this construct. This statement measured effort expectancy and is indicative of lecturers' willingness to use Blackboard in their teaching.

It is interesting to note that even though these participants are using Blackboard, the effort in using Blackboard is not overwhelmingly positive since only about 58 percent of the respondents agree that Blackboard is easy to use (**Table 3**). A possible explanation for this result may be the lack of adequate support.

The Social Influences (SI) that instigate the adoption of blackboard

As can be seen in **Table 4** a total of about 47 percent of the respondents that use Blackboard have indicated that people who are important to them think that they should use Blackboard. The low percentage appears to indicate that social influence is not an important factor that influences Blackboard users.

The Facilitating Conditions (FC) that influence the use of blackboard

According to the UTAUT model the facilitating conditions influences usage behaviour of a system. Of the 19 respondents that are using Blackboard to teach, about 89 percent (**Table 5**) have received training to use Blackboard.

Table 3. Ease of Use of Blackboard

		Frequency	*Percent*	*Valid Percent*	*Cumulative Percent*
Valid	Strongly disagree	2	2.0	10.5	10.5
	Disagree	2	2.0	10.5	21.1
	Neutral	4	4.0	21.1	42.1
	Agree	9	9.0	47.4	89.5
	Strongly agree	2	2.0	10.5	100.0
	Total	19	19.0	100.0	

Table 4. People who are Important to Me Think I Should use Blackboard

		Frequency	*Percent*	*Valid Percent*	*Cumulative Percent*
Valid	Strongly disagree	1	1.0	5.3	5.3
	Disagree	1	1.0	5.3	10.5
	Neutral	6	6.0	31.6	42.1
	Agree	3	3.0	15.8	57.9
	Strongly agree	6	6.0	31.6	89.5
	Don't know	2	2.0	10.5	100.0
	Total	19	19.0	100.0	
Missing	System	81	81.0		
Total		100	100.0		

Table 5. Blackboard Training

		Frequency	*Percent*	*Valid Percent*	*Cumulative Percent*
Valid	Neutral	2	2.0	10.5	10.5
	Agree	7	7.0	36.8	47.4
	Strongly agree	10	10.0	52.6	100.0
	Total	19	19.0	100.0	
Missing	System	81	81.0		
Total		100	100.0		

Table 6. I Have All the Resources to Use Blackboard

		Frequency	Percent (%)	Valid Percent (%)	Cumulative Percent (%)
Valid	Disagree	2	2.0	10.5	10.5
	Neutral	8	8.0	42.1	52.6
	Agree	5	5.0	26.3	78.9
	Strongly agree	4	4.0	21.1	100.0
	Total	19	19.0	100.0	
Missing	System	81	81.0		
Total		100	100.0		

Table 7. The IT Infrastructure Supports My Use of Blackboard

		Frequency	Percent (%)	Valid Percent (%)	Cumulative Percent (%)
Valid	Strongly disagree	1	1.0	5.3	5.3
	Disagree	3	3.0	15.8	21.1
	Neutral	7	7.0	36.8	57.9
	Agree	5	5.0	26.3	84.2
	Strongly agree	3	3.0	15.8	100.0
	Total	19	19.0	100.0	
Missing	System	81	81.0		
Total		100	100.0		

Table 8. Blackboard Support

		Frequency	Percent (%)	Valid Percent (%)	Cumulative Percent (%)
Valid	Strongly disagree	1	1.0	5.3	5.3
	Disagree	3	3.0	15.8	21.1
	Neutral	2	2.0	10.5	31.6
	Agree	8	8.0	42.1	73.7
	Strongly agree	5	5.0	26.3	100.0
	Total	19	19.0	100.0	
Missing	System	81	81.0		
Total		100	100.0		

The chi-square test reveals that "Level of lecturer" was found to correlate with the item ("I have received training on the use of Blackboard"), which means that the more senior a staff member is, the more likely he would have gone for Blackboard training.

About 47 percent of the respondents feel that they have all the necessary resources to use Blackboard (**Table 6**). Since only 10.5 percent of the respondents that use Blackboard have disagreed with the statement: "I have all the resources to use Blackboard", it suggests that respondents have sufficient resources to use Blackboard.

Only about 42 percent (**Table 7**) of the respondents that use Blackboard agree that the IT infrastructure supports their usage of Blackboard. The frequencies of the agreement and disagreement in **Tables 5-8** for the statements that measure facilitating conditions suggest that there is neither significant agreement nor disagreement that the IT infrastructure supports the respondents' use of Blackboard. It is thus likely that respondents are not entirely satisfied with the IT infrastructure at the institution and this may require further investigation.

There seems to be a reasonable amount of Blackboard support among the lecturers (**Table 8**) with approximately 68 percent reporting that they can call upon the assistance of a person or group at their campus if they are having difficulty using Blackboard. To determine to what extent the four constructs in **Table 1** predict usage of Blackboard, (continued usage in this case), it was decided to construct a regression model with the four constructs (**Table 1**) as independent variables, and usage as a dependent variable.

First, Pearson's correlation analysis was performed indicating that while usage is positively correlated with the four (4) constructs (PE, EE, SI and FC), it was however, not significantly correlated. The independent constructs were correlated with each other (some significantly) as is apparent in **Table 9**. **Table 9** shows the inter-correlations among the four independent constructs and the dependent construct (BI).

Table 9. Correlations of the Four Constructs For Users of Blackboard

		PEpos	EEPos	SIPos	FCPos	Usage
PEpos	Pearson Correlation	1	.731**	.364	.520*	.242
	Sig. (2-tailed)		.000	.126	.022	.317
	N	19	19	19	19	19
EEPos	Pearson Correlation	.731**	1	.597**	.549*	.253
	Sig. (2-tailed)	.000		.007	.015	.295
	N	19	19	19	19	19
SIPos	Pearson Correlation	.364	.597**	1	.476*	.257
	Sig. (2-tailed)	.126	.007		.039	.288
	N	19	19	19	19	19
FCPos	Pearson Correlation	.520*	.549*	.476*	1	.348
	Sig. (2-tailed)	.022	.015	.039		.144
	N	19	19	19	19	19
Usage	Pearson Correlation	.242	.253	.257	.348	1
	Sig. (2-tailed)	.317	.295	.288	.144	
	N	19	19	19	19	19

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Facilitating conditions (FC) seemed to have strong association with effort expectancy where $r = 0.549$ and $p=0.015< 0.05$. This association may be explained in part by the fact that the effort required to use the system is strongly influenced by the conditions that prevail, such as technical, pedagogical and support from management.

Similarly facilitating conditions (FC) are strongly associated with performance expectancy (PE) where $r = 0.520$ and $p = 0.022 < 0.05$. This positive association may be due to the fact that if the facilitating conditions for using the system are in place such as, adequate training and support for using the system, then it is likely that more use of the system would result which in turn will influence the performance expectancy (PE). Performance expectancy (PE) seems to be strongly correlated with effort expectancy where $r = 0.731$ and $p=0.000 < 0.05$. It is expected that if one finds the system easy to use then the system lends itself to being used or adopted which in turn is likely to influence performance expectancy (PE).

More importantly, facilitating conditions have the highest correlation with the dependent variable, usage, but is not significant, where $r = 0.348$ and $p= 0.144> 0.05$. According to Pallant (2010) in order to perform a multiple regression analysis, the independent variables should correlate with each other with a correlation of not greater than 0.7 and the independent variables should correlate with the dependent variable with at least 0.3. Based on these results, and the fact that the sample size for the users of Blackboard was small, it was not worthwhile to conduct a multiple regression analysis on the set of variables.

Let us now turn to the analysis of non-users of Blackboard.

Analysis of Non-Users of Blackboard

A study of the perceptions of lecturers who do not use Blackboard will assist in gaining a better understanding of the slow adoption rate of Blackboard.

Figure 2 shows the perceptions and experiences of Blackboard of the cohort of participants who do not use Blackboard.

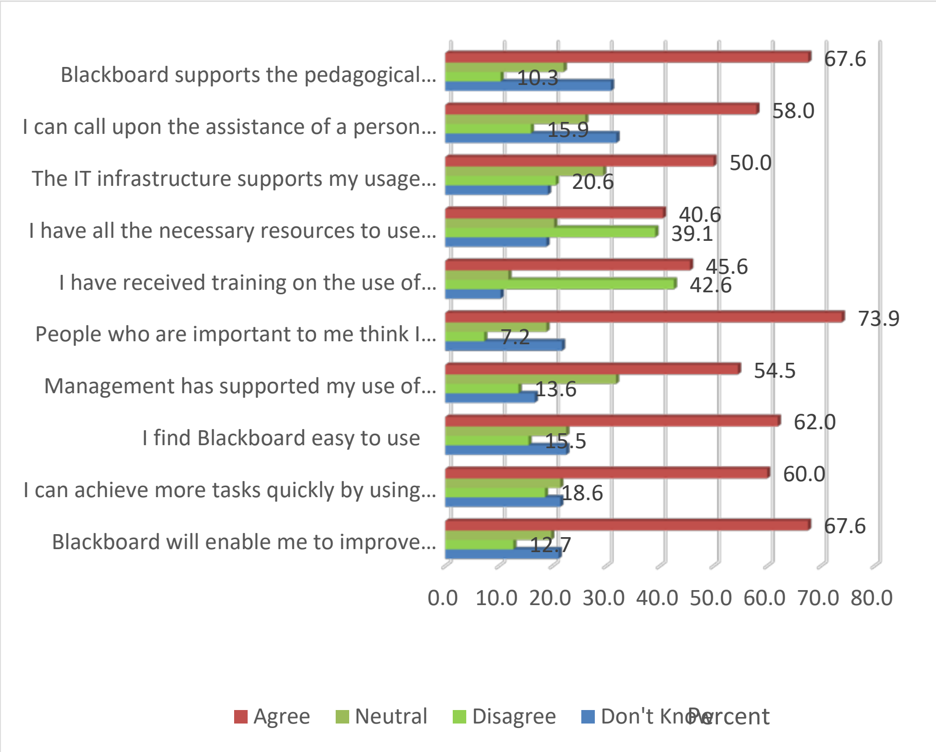

Figure 2. Ratings of staff perceptions of Blackboard

The influence of *performance expectancy* (PE) on intention to use Blackboard – a significant number of staff members who are not using Blackboard have agreed with the items that measured performance expectancy, that is Blackboard enables them to improve the effectiveness of their lecturing, they can achieve more tasks quickly by using Blackboard, and Blackboard supports the pedagogical principles in my lecturing.

The influence of *effort expectancy* (EE) – **Figure 2** indicates that 62 percent of staff who do not use Blackboard perceive the use of Blackboard to be easy to use.

The *social influences* (SI) that instigate the adoption of Blackboard – a significant number (73.9%) of staff who are not using Blackboard have agreed with the statement "People who are important to me think I should use Blackboard" (**Figure 2**).

It would appear that social influence would positively affect non-users intention to use Blackboard.

The *facilitating conditions* (FC) that influence the use of Blackboard - Only 13.6 percent of the respondents that are not using Blackboard felt that Management has not supported their use of Blackboard, which implies that there is fairly good Blackboard support from management.

Approximately 46 percent of the staff that are not using Blackboard have received training on Blackboard and were in agreement with the statement: "I have received training on the use of Blackboard." However, about 43 percent disagreed with this statement which implies that they have not received training on Blackboard.

Approximately 39.1 percent of the respondents felt that they do not have all the resources to use Blackboard. This is close to the number of respondents that felt they have all the resources to use Blackboard which is about 41 percent. The reason for the small difference could be due to the difference in their perceived computer proficiency. Half the number of staff that are not using Blackboard feel that the IT infrastructure supports their usage of Blackboard. There seems to be an adequate amount of Blackboard support with 58 percent of the respondents agreeing with the statement: "I can call upon the assistance of a person or group at my campus if I am having difficulty using Blackboard."

Multiple regression analysis for non-users

In order to answer the second research question, to what extent do the four constructs of the PE, EE, SI and FC contribute to the variance of the criterion variable "intention to use", multiple regression analysis was conducted.

Table 10. Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.408[a]	.166	.152	1.019	.166	11.971	1	60	.001

a. Predictors: (Constant), FC

Table 11. Coefficients of predictor variable(s)

Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.	Correlations		
		B	Std. Error	Beta			Zero-order	Partial	Part
1	(Constant)	.583	.510		1.144	.257			
	FC	.553	.160	.408	3.460	.001	.408	.408	.408

a. Dependent Variable: IU

The values for intention to use Blackboard (IU) was coded using a Likert scale based on the comments given in the open-ended questions, where 1= No intention to use Blackboard, 2= May use Blackboard, 3= Neutral, 4= intend using Blackboard and 5= Have a strong intention to use Blackboard.

Stepwise multiple regression was then performed to assess the ability of the four constructs, performance expectancy (PE), effort expectancy (EE), social influence (SI) and facilitating conditions (FC) to predict intention to use or adopt the learning management system, Blackboard. Note that multiple regression was set to exclude cases listwise variables**.** Hence, from the sample of 81 (non-users), SPSS analysed the data from only 62 participants who had no missing values. **Tables 10** and **11** show the results obtained from the regression analysis

The final model (**Table 10**) to emerge from the stepwise analysis contains only one predictor variable, facilitating condition (FC) in the first step as shown in **Table 11**, where adjusted R square = 0.152; F(1, 62) = 11.97, p = 0.001 (using the stepwise method).

The three constructs, performance expectancy (PE), effort expectancy (EE) and social influence (SI) were not significant predictors in this model. The analysis indicated weak correlations between behavioural intention to use Blackboard and the independent variables, performance expectancy, effort expectancy, and social influence. In this study, the regression model accounts for only a small percentage (15%) of variance in the dependent variable (intention to use), that is, the model explains 15 percent of the variance. It would appear that the model is significant, where p=0,001, in which facilitating conditions appeared to be the best predictor of intention to use Blackboard. However, this finding still did not explain the slow adoption of Blackboard.

On examining the responses from the open-ended question, an interesting theme emerged, time required to attend training and set up courses in Blackboard. This may account for the slow adoption of Blackboard. The excerpt from one of the respondents reflects this interpretation.

> *Most lecturers are required to spend an inordinate amount of time doing administrative work and engaging in compliance-related activities which contribute very little to truly improving the quality of education at …. This leaves little time for anything creative or innovative regarding academic work*

DISCUSSION

The study has shown that the majority of the participants were fairly knowledgeable and proficient in computing, a precursor for the adoption of a LMS. Interestingly, for both users and non-users of Blackboard, the results show that the three constructs, PE, EE, and SI were weakly correlated with behavioural intention. However, while facilitating conditions (FC) were moderately correlated with behavioural intention for Blackboard users, FC was significantly correlated with behavioural intention for the non-users of Blackboard. Furthermore, multiple regression analysis revealed that FC is the predictor of intention to use Blackboard. This result has implications for practice. From the items used to measure perceptions of staff as indicated in **Figure 2**, it would appear that the figures show that they are largely positive about the use of Blackboard. Additionally, the independent constructs were correlated with each other (some significantly) as is apparent in the **Table 9**.

Facilitating conditions (FC) seemed to have strong association with effort expectancy. This association may be explained in part by the fact that the effort required to use the system is strongly influenced by the conditions that prevails, such as support from management.

Similarly facilitating conditions (FC) were also strongly associated with performance expectancy (PE). If the facilitating conditions for using the system are all in place, such as adequate training and support for using the system, then it is likely that the result thereof is more usage of the system which in turn leads to the system assisting one in one's job.

Performance expectancy (PE) seems to be strongly correlated with effort expectancy. This relationship may be explained due to the fact that if one finds the system easy to use then this results in one using the system which then assists one in doing one's job.

Most importantly facilitating conditions were found to have the highest correlation with the dependent variable, usage, which was significant for the non-users. This finding broadly supports the work of Kulshrestha and Kant (2013), although different aspects of facilitating conditions were identified in their study. While most items that measured facilitating conditions were positive, the adoption rate is low. On closer examination of the write in-comments from the open-ended question revealed an important aspect – Time required to attend Blackboard training and to set up an online classroom was not enough. Huge workloads emerged as not having sufficient time to be innovative.

SUGGESTIONS FOR FUTURE RESEARCH

The study has revealed that a large percentage of staff respondents who have undergone Blackboard training are currently not using the LMS for teaching and learning. Some staff who have been for Blackboard training have also subsequently migrated to an alternate LMS and indicated that Blackboard is not user friendly and difficult to use. Thus it will be interesting to research the usability of Blackboard since this could be a reason as to why some staff have migrated to an alternate LMS such as Moodle.

LIMITATIONS

The response rate was lower than expected; hence a higher rate of response might result in a better prediction of the influencing factors. The sample size was smaller than planned for which could affect the results. Hence these findings may not be generalisable to a broader range of staff or institutions.

CONCLUSION

The study identified factors that influence the adoption of Blackboard by academic staff at the institution by considering the constructs from the UTAUT model – performance expectancy, effort expectancy, social influence and facilitating conditions. Notwithstanding the relatively limited sample, this work offers valuable insights into the adoption of a LMS. One of the more significant findings to emerge from this study is that facilitating conditions need to be addressed for the successful adoption and use of Blackboard, consistent with Kulshrestha and Kant's (2013) study with some variation in the items of 'facilitating conditions'. Time to learn, set up courses online and continual support during the use of Blackboard emerged as key findings. These views surfaced mainly in relation to the high workloads that staff carry. Academic staff – both users and non-users of Blackboard – were found to be in agreement that Blackboard will enable them to improve their teaching and learning. This study produced results that are similar to that of Maina and Nzuki's (2015) findings regarding positive impact of performance expectancy on intention to use Blackboard. It is therefore vital that a concerted effort is required from management in supporting academic staff in the use of the LMS, Blackboard. These findings have implications for management to implement a structured support programme to assist staff in developing and using the LMS efficiently.

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Who Needs Entrepreneurial Role Models? Driving Forces of Students' Cyber-Entrepreneurial Career Intention

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ABSTRACT

Cyber-entrepreneurship has become an important topic of debate in academia primarily because of an increasingly competitive nature of E-commerce industry and internet. Since cyber-entrepreneurial career-decision encompasses higher degree of personal risks and commitments among those aspiring to become 'cyber-entrepreneurs', there is need for in-depth understanding on the driving factors that influencing Cyber-entrepreneurial intentions. By integrating the concepts of social cognitive theory and goal-setting theory, the current research aims to explore the effects of Cyber-entrepreneurial self-efficacy (CESE) and goal commitment (GC) on Cyber-entrepreneurial intentions (CEIs) in the context of undergraduate entrepreneurship education, and inquires whether the presence of entrepreneurial role models (ERMs) has any effect on the CEIs among undergraduates. Structural equation modeling and multi-group analysis were used to analyze the data collected from 279 undergraduate students from several universities in Taiwan—among which 146 were with entrepreneurial role models and 143 were without. The results showed that GC has a partial mediation effect between CESE and CEI only in the cases of students without ERMs. Multi-sample SEM revealed a significant difference between the effects of CESE on CEI in students with and without ERMs. These findings may have important theoretical and practical implications to students undertaking entrepreneurship degrees and those making leap-decisions to enter the cyber-entrepreneurial field.

Keywords: career decisions, cyber entrepreneurial intentions, cyber entrepreneurial self-efficacy, entrepreneurship education, goal commitment

INTRODUCTION

The advancement of information and communication technology has led to a boom in e-commerce and created an alternative to traditional entrepreneurship. Today, e-commerce accounts for 89.7% of the global annual sales amount, and is mainly concentrated in three regional markets – Asia-Pacific, North America, and Western Europe. Comparatively, Asia-Pacific demonstrates the strongest potential growth with the expected compound annual growth rate increase to 15.8% in 2014 (eMarketer, 2014). The emergence of mobile technology in recent years further launched cyber entrepreneurship into an innovative, dynamic and cost-effective alternative to the traditional model (Matlay & Westhead, 2007; Wang et al, 2016). In light of these changes, the Taiwanese government has proposed relevant policies to promote the growth and development of the e-commerce industry and entrepreneurship; cyber-entrepreneurship-related courses, therefore, have also flourished in Taiwanese universities (Ministry of Economic Affairs, 2016).

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Contribution of this paper to the literature

- Integrating the concepts of social cognitive theory and goal-setting theory, the current research explored the effects of Cyber-entrepreneurial self-efficacy (CESE) and goal commitment (GC) on Cyber-entrepreneurial intentions (CEIs) in the context of undergraduate entrepreneurship education, and further investigated whether the presence of entrepreneurial role models (ERMs) has any effect on the CEIs of students.
- Research results showed that students' CESE has positive effect on their GC and CEIs individually, and their GC has a positive effect on their CEIs. However, GC only has a partial mediation effect between CESE and CEIs in no presence of entrepreneurial role models (NERMs) but not in presence of entrepreneurial role models (PERMs).
- This research concluded that cyber-entrepreneurship educators and practitioners will be able have a better understanding of the students' CESE through their levels of GC, and come up with better methods or designs for the entrepreneurial curricula that will further promote students' CEIs.

Creativity, innovation, and entrepreneurship have been integrated into one widely-discussed hot topic in higher education (Edwards-Schachter et al, 2015; Lubart, 2008). These concepts increasingly recognized as the engines that foster an entrepreneurial culture (OECD, 2011). Creative thinking aims to explore and formulate the originality, take risks and tolerate ambiguity to bring the value of creative act, product, or idea (Anderson, Thier, & Pitts, 2017). Creative skills enable students to discover ideas and opportunities conducive to innovation; entrepreneurship programs and courses provide the context and materials that allow students to learn and apply skills and behaviors needed to create value in entrepreneurial firms (Gundry, Ofstein, & Kickul, 2014). The incorporation of these topics as part of the 'core competency' of educational programs has become a central theme in the face of today's turbulent markets and the complex demands by the rapid technological and societal changes (Gattie, Kellam, Schramski, & Walther, 2011; Vanevenhoven, 2013).

Interdisciplinary learning is an important part of talent cultivation. Entrepreneurship education aims to offer students alternative career choices by fostering their entrepreneurial intentions and skills (Huang, 2017; Jiang, Xiong, & Cao, 2017; Sánchez, 2011). Furthermore, entrepreneurial courses further enabled the students to balance theory and practice through the principle of learning by doing to choose to start their own business (Wu, Kuo, & She, 2013).

With the encouragement of the Taiwanese government, innovation and entrepreneurship platforms have been established one after another by colleges and universities, and entrepreneurship courses increased sevenfold over the past ten years (Ministry of Education, 2016). For example, TiC100, founded in 1999 by Advantech, provided the entrepreneurial events by means of entrepreneurial contests, innovative business model competitions and internet of thing (IoT) application development contests to cultivate thousands of university students' into entrepreneurship fields (TiC 100, 2018). Furthermore, to assist young people to start-up their own business, the Ministry of Education Youth Development Department (2012) promulgates "…cultivating quality manpower and promoting employment programs" to provide venture fund and incubators for university graduates who showed and demonstrate entrepreneurial intentions and competencies.

In spite of government efforts, less than 25.9% (ranked 53rd among the 54 economies) of the Taiwanese adults believe they have entrepreneurial capabilities even though 71.1% (11th) of them believe entrepreneurship to be a good career choice. Moreover, Taiwan ranked 22nd in the fear of failure during entrepreneurial process category (Global Entrepreneurship Research Association, 2018). One probable explanation is that the cost of entrepreneurial opportunities might be higher for the highly educated technicians and professionals, and that their risk of failure might be greater in entrepreneurship than in employment (Liu, Wen, & Hsieh, 2011). This discrepancy between entrepreneurial intentions and behaviors highlights the importance of having educational programs and curricula designed to foster the development of entrepreneurship (Geldhof et al, 2014). Previous findings have already shown that participation in entrepreneurial courses has a positive effect on people's entrepreneurial potential and attitudes (Stokes & Wilson, 2010). The investigation of the factors that influence CEIs and their causal relationships is therefore of paramount importance to entrepreneurship education.

Studies have found that the environmental and situational factors and opportunities can directly affect an individual's career (Callanan & Zimmerman, 2016; Liñán & Fayolle, 2015; Shepherd, Williams, & Patzelt, 2015). The role of self-efficacy in occupational choice and preparation has been the focus of research on career choice and development in social cognitive theory (Betz & Hackett, 1997; Lent, Brown, & Hackett, 1994). This study helps to clarify the impact of self-efficacy on decision-making behaviors. However, several publications have claimed that the belief in one's capabilities not only has no determinative function, it can even be self-deprecating (Vancouver et al, 2002; Vancouver, Thompson, & Williams, 2001). For their part, Bandura and Locke (2003) presented a large body of evidence that disproved such findings. Confronted with these contradictory results, further investigation is required to verify if CESE and other factors indeed affect cyber-entrepreneurial career decisions and if so, in what ways for potential/aspiring cyber entrepreneurs.

The goal-oriented behavior of entrepreneurs is becoming an area of great interest among researchers. Commitment is a force that binds an individual to a course of action and its associated target (Meyer, Becker, & Van Dick, 2006). While self-efficacy may be a motivational or de-motivational force depending on a person's self-enhancing or self-deprecating beliefs (Bullough & Renko, 2013), GC might be one of its determining factors (Callanan & Zimmerman, 2016; Przepiorka, 2016). Goal-setting theory proposed four mechanisms through which goals affect performance: choice, effort, persistence, and strategies (Locke & Latham, 2002). For entrepreneurs, the decision to start a company is the result of careful planning and deliberate action that entails great energy and commitment. Goal commitment is an individual's willing to accomplish his/her setting target (Locke, Shaw, Saari, & Latham, 1981) and it will be influenced by self-efficacy (Locke & Latham, 2002). Entrepreneurial educators could improve students' entrepreneurial self-efficacy by entrepreneurial role modeling or entrepreneurial models with whom the aspiring/wannabe entrepreneurs can identify (Bandura, 1997; Locke & Latham, 2002; White & Locke, 2000). Moreover, Callanan and Zimmerman (2016) suggested the application of a structured career management model to all phases of the entrepreneurial career decision-making process; and pointed out that the establishment of realistic goals can facilitate the development and implementation of career strategies. The present study seeks to integrate the concepts of social-cognitive theory and goal-setting theory in examining the relationships among CESE, GC, and CEI to effectively promote students' CEI in the context of undergraduate education.

Entrepreneurship education and entrepreneurial role models both have impacts on the entrepreneurial intentions of students in developing countries (Muofhe & Du Toit, 2011). Muofhe and Du Toit (2011) observed that positive relationships exist between entrepreneurship education and entrepreneurial intentions, and entrepreneurial role models and entrepreneurial intentions. Some studies have also confirmed that the entrepreneurial competence of young adults is predictable by their entrepreneurial personality traits, the authoritative parenting style of their parents, and the presence of entrepreneurial role models in their lives (Obschonka, Silbereisen, & Schmitt-Rodermund, 2011). Adult entrepreneurial mentors such as parents may be the key to the development of entrepreneurial intentions in young adults careers (Schmitt-Rodermund, 2004). In light of the above, we divided our samples into the categories of students who have the presence of entrepreneurial role models in their lives (PERMs) and students who do not have (NERMs) to compare and explore the differences between their CESEs, GCs, and CEIs. Here, ERMs refer to family member, teachers/professors, and/or friends.

THEORETICAL FRAMEWORK AND HYPOTHESES

The Effect of Students' Cyber-Entrepreneurial Self-Efficacy (CESE) on their Cyber-Entrepreneurial Intentions (CEIs)

The making of an entrepreneur is dependent on the contribution of multiple factors, e.g., personal attributes, background, experience and trait combinations (Arenius & Minniti, 2005; Baron, 2004; Shane, Locke, & Collins, 2003). One of such factors is entrepreneurial self-efficacy (ESE). It refers to a person's ability to believe that he/she can successfully achieve the tasks necessary for an entrepreneur (McGee, Peterson, Mueller, & Sequeira, 2009). Commitment can be accompanied by different ways of thinking that plays a role in shaping behavior and may even lead to the persistence to a course of action, even in the face of conflicting motives or attitudes (Meyer & Herscovitch, 2001). ESE has a high degree of influence over the entrepreneurial intention of and the extent of effort made by a potential entrepreneur; and it affects his/her willingness to withstand the changes and challenges they encounter during the entrepreneurial process in order to become a successful entrepreneur (Trevelyan, 2011).

ESE is an important antecedent and an effective predictor of entrepreneurial intentions (Barbosa, Gerhardt, & Kickul, 2007; McGee et al., 2009). Empirical studies have confirmed its significant effect on students' entrepreneurial intentions (BarNir, Watson, & Hutchins, 2011; Carr & Sequeira, 2007; Kickul, Gundry, Barbosa, & Whitcanack, 2009; Liñán, 2008; Piperopoulos & Dimov, 2015; Sesen, 2013; Zhao, Seibert, & Hills, 2005). Base on the above claims findings, we propose the following hypothesis.

H1: Students' CESE has a positive effect on their CEI. ($X \rightarrow Y$, c)

The Effect of Students' Cyber-Entrepreneurial Self-Efficacy on their Goal Commitment

An established goal is a driving force that makes people focus, take action, persist and persevere in tackling with increasingly difficult tasks until the desired outcome is achieved (De Clercq, Menzies, Diochon, & Gasse, 2009). Self-efficacy, on the other hand, affects an individual's goal setting (Boyd & Vozikis, 1994), and is proven to be an important factor conducive to the enhancement of goal commitment (Locke & Latham, 2002). Empirical studies have shown that when an individual's self-efficacy is higher, their goal commitment becomes stronger as well (De

Clercq et al., 2009; Locke, Frederick, Lee, & Bobko, 1984; Wood & Bandura, 1989; Wu, 2002). In light of that, the following hypothesis is proposed.

H2: Students' CESE has a positive effect on their GC. (X→M, a)

The Mediation of Goal Commitment

An individual's self-efficacy and personal goals are both important factors that influence their behavior (Bandura, 1997). Strong commitment to the goal and strong intentions to achieve it are demonstrated when one can accurately anticipate that the result of achieving the goal is important (Locke & Latham, 2002). A person's goal commitment mediates the effect his/her self-efficacy has on their learning performance (Chu & Peng, 2009). Moreover, entrepreneurial passion has the positive effects on new venture growth through the mediation of goal commitment (Drnovsek, Cardon, & Murnieks, 2009). According to the literature of organizational behavior, employees who are committed to specific challenging goals outperform those who either do not have goals or have only a weak commitment to them (Locke & Latham, 2006). Goal setting has the advantage of helping the entrepreneur direct his/her efforts in a more focused manner (Callanan, & Zimmerman, 2016).

Moreover, once the goals are in place, complementary behaviors and attitudes that reinforce them will occur naturally (Locke & Latham, 2006). Goals and self-efficacy have been found to have direct effects on venture growth and to mediate the effects of passion, tenacity, and new resource skills on subsequent growth (Baum & Locke, 2004).

Goal commitment, on the other hand, has been studies and verified to be important at different stages of the entrepreneurial process (Przepiorka, 2016). Empirical studies have found out that entrepreneurial role models (i.e., parents) not only predicted entrepreneurial intentions (Geldhof et al., 2014; Schmitt-Rodermund, 2004), but also the development of entrepreneurship (Bosma et al, 2012; McClelland, 1961). Considering all of the above, the following hypotheses were proposed.

H3: Students' GC has a direct effect on their CEI. (M→Y, b).

H4: Students' GC mediates effect their CESE has on their CEI (X, M→Y, a*b, c').

H5: The presence or no presence of ERMs (PERMs/NERMs) has a significant categorical mediation effect on the relationship among model constructs.

Figure 1 showed the research model and illustrated the relationship among the 4 hypotheses.

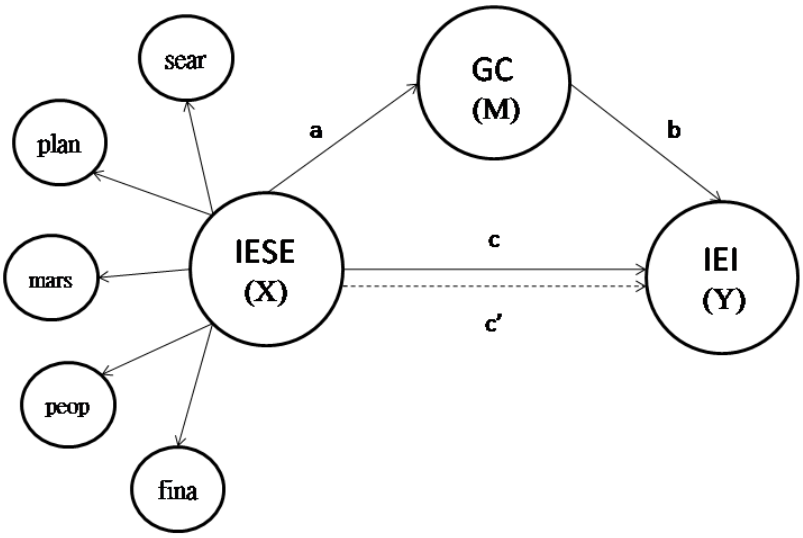


Figure 1. Research Model

METHODOLOGY OF RESEARCH

Samples and Procedure

All participants were undergraduate students from the colleges and universities in Taiwan. Armstrong and Overton (1977) suggested that researchers could divide the questionnaires into two groups, the first two weeks (n=130) and the last two weeks (n=149) according to the survey interval, to test the differences of constructors. Therefore, this study conducts the t-test (CESE t=0.244, p>.05; GC t=1.270, p>.05; CEI t=0.804, p>.05) ($p > 0.05$) to ensure that the samples does not suffer from bias.

This study is part and parcel of the cyber entrepreneurship education program, so the participants were asked to first write down one e-commerce- or entrepreneurship-related course they had taken before they proceeded to complete the questionnaire. Of the 279 viable samples, 146 students had entrepreneurial role models (PERMs) and 133 students had none (NERMs); 55.9% were males and 44.1% were females; 52.3% majored in business (or information) management, 29.8% majored in science, engineering and technology, 7.5% majored in education, 6.1% majored in medicine, and 4.3% majored in others subjects. The majority (82%) undertook in the business-management and science/engineering/technology (STEM) majors (see **Table 1**).

Table 1. Number and Percentage of Students in Each Major

	Population		Sample	
Major	**Number**	**Percentage (%)**	**Number**	**Percentage (%)**
Science, Engineering and Technology	327,272	36.54	83	29.75
Business Management	263,415	29.41	146	52.33
Education	21,386	2.39	21	7.53
Medicine	92,437	10.32	17	6.09
Others	191,234	21.35	12	4.30
Total	895,744	100.00	279	100.00

Measuring Instruments

To ensure construct validity, items selected for the measurement of constructs here were mainly adapted from previous studies and slightly modified to fit the context of cyber entrepreneurship. The instruments used to measure CESE, GC, and CEI were as follows:

Cyber-Entrepreneurial Self-Efficacy (CESE)

Our "Cyber Entrepreneurial Self-Efficacy (CESE) Scale" was adapted from the "Entrepreneurial Self-Efficacy (ESE) Scale" developed by McGee et al. (2009). The items in the measure were pretested by experts associated with the fields of cyber entrepreneurship and entrepreneurship education, and then adjusted to ensure articulacy. The scale contains 18 items divided into five subscales of searching, planning, marshaling, implementing-people, and implementing-financial. It employs a 5-point Likert scale ranging from the choices of "strongly disagree" to "strongly agree". Higher scores signified higher levels of confidence. Sample questions were "Brainstorm (come up with) a new idea for a product or service" (Searching), "Estimate customer demand for a new product or service" (Planning), "Get others to identify with and believe in my vision and plans for a new business" (Marshaling), "Supervise employees" (Implementing-people), and "Organize and maintain the financial records of my business" (Implementing-financial).

Goal Commitment (GC)

The 4-item scale we used to measure goal commitment was derived from the 4-item model designed by Klein et al. (2001). A 5-point Likert scale was used with choices ranging from "strongly disagree" to "strongly agree". Higher scores signified higher degrees of commitment to the goal. Sample questions were "I am strongly committed to pursuing this goal" and "I think this is a good goal to shoot for".

Cyber-Entrepreneurial Intentions (CEI)

We compiled our "Cyber-Entrepreneurial Intentions (CEI) Scale" based on the "Entrepreneurial Intentions (EI) Scale" developed by Liñán and Chen (2009). The resultant 6-item 5-point Likert scale offered answer choices ranging from "strongly disagree" to "strongly agree". Higher scores indicated stronger desire for cyber entrepreneurship. Sample questions were "My professional goal is to become a cyber entrepreneur", and "I have a strong ambition to start a cyber enterprise someday".

Data Analysis

Partial least squares (PLS) testing was performed using the Smart PLS 3.2.6 software (Ringle, Wende, & Becker, 2015) to examine and analyze the measurement and structural model of the total sample and the two subsamples

(PERMs and NERMs). First, we tested the validity of all scales with a confirmatory factor analyses (CFAs) to ensure the convergent validity of the tools. Secondly, we applied partial least squares structural equation modeling (PLS-SEM), using the Bootstrap resampling technique to resample 5,000 times (Hair, Ringle, & Sarstedt, 2011) to examine the significance and predictability (R^2) of the path coefficients in the structural model and to determine the goodness of fit with the standardized root mean square residual (SRMR). Lastly, we conducted PLS-MGA (multi-group analysis) to verify the difference in structural model between the PERMs and NERMs. For the differences in path coefficients, we opted for the permutation-based test procedures (Chin & Dibbern, 2010). The significance of the differences between the estimated parameters of the two, taken into consideration both the equal and different variances, was determined using the parametric approach (Chin, 2010).

RESULTS OF RESEARCH

Descriptive Statistical Analysis

Before analyzing the structural models, an independent samples *t*-test was conducted to determine whether significant differences existed between the variables of PERMs and NERMs. As illustrated in **Table 2**, no significant difference in GC was detected between the two groups; but in CESE and CEI, significant differences were detected. The mean values of both CESE and CEI were significantly higher in PERMs (CESE: M = 3.494, t = 3.421, p < 0.01; CEI: M = 3.032, t = 2.150, p< 0.05) than in NERMs and Total Students. This finding suggested the significant effect of PERMs on the CESE and CEI of students, which therefore called for the multi-group analysis (MGA) we subsequently performed.

Table 2. Descriptive Statistics for Total Students, PERMs and NERMs

Contracts	Total Students (n = 279)		PERMs (n = 146)		NERMs (n = 133)		Significance of difference between PERMs and NERMs	
	Mean	*SD*	*Mean*	*SD*	*Mean*	*SD*	*t-value*	*sig.*
CESE (X)	3.386	0.562	3.494	0.558	3.268	0.543	3.421	**
GC (M)	4.096	0.445	4.125	0.439	4.064	0.452	1.145	ns
CEI (Y)	2.943	0.722	3.032	0.760	2.847	0.668	2.150	*

Notes: SD: standard deviation. PERMs = presence of entrepreneurial role models; NERMs = no entrepreneurial role models; CESE = cyber-entrepreneurial self-efficacy; GC = goal commitment; CEI = cyber-entrepreneurial intentions.
*p <0.05, **p < 0.01 (two-tail t distribution)

Reliability and Validity of the Scales

First, we examined the measurement model. The results of PLS analysis revealed that the factor loadings of all measuring instruments were above 0.7, signifying indicator and construct reliability; the values of composite reliability (CR) all exceeded 0.7, signifying high internal consistency of measures; and the average variance extracted (AVE) values all exceeded the 0.5 benchmark (Hair, Anderson, Babin, & Black, 2009; Hair, Hult, Ringle, & Sarstedt, 2014), signifying the convergent validity of our instruments (See **Table 3**).

Table 4 shows the discriminant validity of each measure. The square roots of the AVE of our constructs (CESE, GC, and CEI) were all greater their correlations with each other (Fornell & Larcker, 1981); the heterotrait-monotrait (HTMT) values of all instruments were below the more conservative threshold value of 0.85 (Henseler, Ringle, & Sarstedt, 2015), thus confirming the excellent discriminant validity of the scales.

Table 3. Composite Reliability of the Scales

Construct/Indicator		Total Sample; n = 279			PERMs; n = 146			NERMs; n = 133		
2nd-order	**1st-order**	**Loading**	**CR**	**AVE**	**Loading**	**CR**	**AVE**	**Loading**	**CR**	**AVE**
CESE			0.901	0.645		0.899	0.643		0.895	0.631
	search	0.829	0.893	0.735	0.816	0.906	0.763	0.830	0.866	0.683
	plan	0.831	0.830	0.619	0.839	0.830	0.619	0.819	0.829	0.618
	marsh	0.823	0.843	0.641	0.822	0.861	0.674	0.817	0.815	0.595
	people	0.822	0.900	0.600	0.839	0.898	0.595	0.797	0.899	0.598
	financial	0.703	0.908	0.766	0.681	0.906	0.764	0.702	0.901	0.754
	GC		0.853	0.593		0.868	0.624		0.838	0.565
	gc_1	0.719			0.722			0.707		
	gc_2	0.835			0.856			0.813		
	gc_3	0.793			0.800			0.799		
	gc_4	0.727			0.775			0.678		
	CEI		0.933	0.737		0.939	0.756		0.925	0.711
	cei_1	0.869			0.878			0.873		
	cei_2	0.811			0.829			0.794		
	cei_3	0.872			0.888			0.836		
	cei_4	0.898			0.906			0.883		
	cei_5	0.840			0.845			0.826		

Notes: PERMs = presence of entrepreneurial role models; NERMs = no entrepreneurial role models; CESE = cyber-entrepreneurial self-efficacy; GC = goal commitment; CEI = cyber-entrepreneurial intentions. CR: Composite reliability; AVE: Average variance extracted.

Table 4. Discriminant Validity of the Scales

Fornell-Larcker Criterion									
	Total sample; n = 279			PERMs; n = 146			NERMs; n = 133		
Construct	**CESE**	**GC**	**CEI**	**CESE**	**GC**	**CEI**	**CESE**	**GC**	**CEI**
CESE	**0.803**			**0.803**			**0.795**		
GC	0.431	**0.770**		0.445	**0.790**		0.409	**0.752**	
CEI	0.439	0.355	**0.858**	0.559	0.365	**0.870**	0.267	0.338	**0.843**
Heterotrait-Monotrait Ratio (HTMT)									
	Total sample; n = 279			Model; n = 146			No-Model; n = 133		
Construct	**CESE**	**GC**	**CEI**	**CESE**	**GC**	**CEI**	**CESE**	**GC**	**CEI**
CESE									
GC	0.521			0.528			0.493		
CEI	0.493	0.413		0.626	0.413		0.292	0.394	

Notes: Fornelle-Larcker Criterion: Diagonal elements (bold) are the square root of the variance shared between the constructs and their measures (AVE). Off-diagonal elements are the correlations among constructs. For discriminant validity, diagonal elements should be larger than off-diagonal elements. PERMs = presence of entrepreneurial role models; NERMs = no entrepreneurial role models; CESE = cyber-entrepreneurial self-efficacy; GC = goal commitment; CEI = cyber- entrepreneurial intentions.

Structural Model and Hypothesis Testing for the Mediation Effects

Structural model fit

Next, we examined the structural model before we proceeded to hypotheses testing. Hair et al. (2011) suggested that collinearity could be a potential issue when the variance inflation factor (VIF) value is 5 or above. Our collinearity assessment results showed that the inner VIF values of the total sample and the two subsamples were all lower than 5 (CESE→GC [1.000, 1.000, 1.000]; GC→CEI [1.228, 1.247, 1.200]; CESE→CEI [1.228, 1.247, 1.200]), indicating the absence of collinearity between predictor variables (Hair et al., 2011).

In assessing the structural model fit, the standardized root mean square residual (SRMR) was applied (Henseler et al., 2014). The results showed that the SRMR values of our total and sub- samples were all above than 0.08 (SRMR has a 0-1 range), and however values as high as 0.08 are deemed acceptable (Total sample, SRMR=0.087; PERMs, SRMR=0.093; NERMs, SRMR=0.099) (Hu & Bentler, 1999). The causal relationships within latent variables were verified using PLS-SEM; the explanatory power of our study was determined by the use of R-squared (R^2) (Pavlou & Fygenson, 2006).

Multi-group analysis

The permutation algorithm was used to carry out the measurement invariance of composite models (MICOM) presented by Henseler, Ringle, and Sarstedt (2016). The purpose of checking measurement invariance is to verify that the factors are indeed measuring the same underlying construct within each group. It is therefore a prerequisite to conducting MGA tests. The results are shown in **Table 5**. As can be seen, our data corroborated the configural, compositional and scalar invariance; "full measurement invariance" was therefore obtained, signifying the cross-sample validity and stability of our scales.

Table 5. Measurement Invariance (MICOM) Tests

Composite	Correlation c value (=1)	95% confidence interval	Compositional invariance?
Compositional invariance			
CESE	1.000	[0.999; 1.000]	Yes
GC	0.996	[0.983; 1.000]	Yes
CEI	0.999	[0.998; 1.000]	Yes
Composite Scalar invariance	**Difference of the composite's mean value (=0)**		**Equal mean values?**
CESE	0.001	[-0.235; 0.235]	Yes
GC	0.001	[-0.231; 0.237]	Yes
CEI	-0.002	[-0.235; 0.241]	Yes
Composite	**Logarithm of the composite's variances ratio (=0)**		**Variances values?**
CESE	0.000	[-0.395; 0.396]	Yes
GC	0.000	[-0.368; 0.372]	Yes
CEI	0.001	[-0.365; 0.381]	Yes

Note: 5000 permutation run; two-tailed 0.05 significance level.

We proceeded to compare the mediating path coefficients of the PERMs and NERMs using the permutation test (5000 permutation runs; two-tailed 0.05 significance level) to determine whether there were significant differences. As shown in **Table 6**, there were significant differences in the coefficients of the total effects of CESE on CEI (p = 0.004 < 0.01) and the coefficients of the direct effect of CESE on CEI (p = 0.005 < 0.01) between the two groups; but no significant difference was detected in the coefficients of the direct effects of CESE on GC or GC on CEI, or the indirect effect of GC on the CESE-CEI relationship between the groups. H5 was therefore only partially supported.

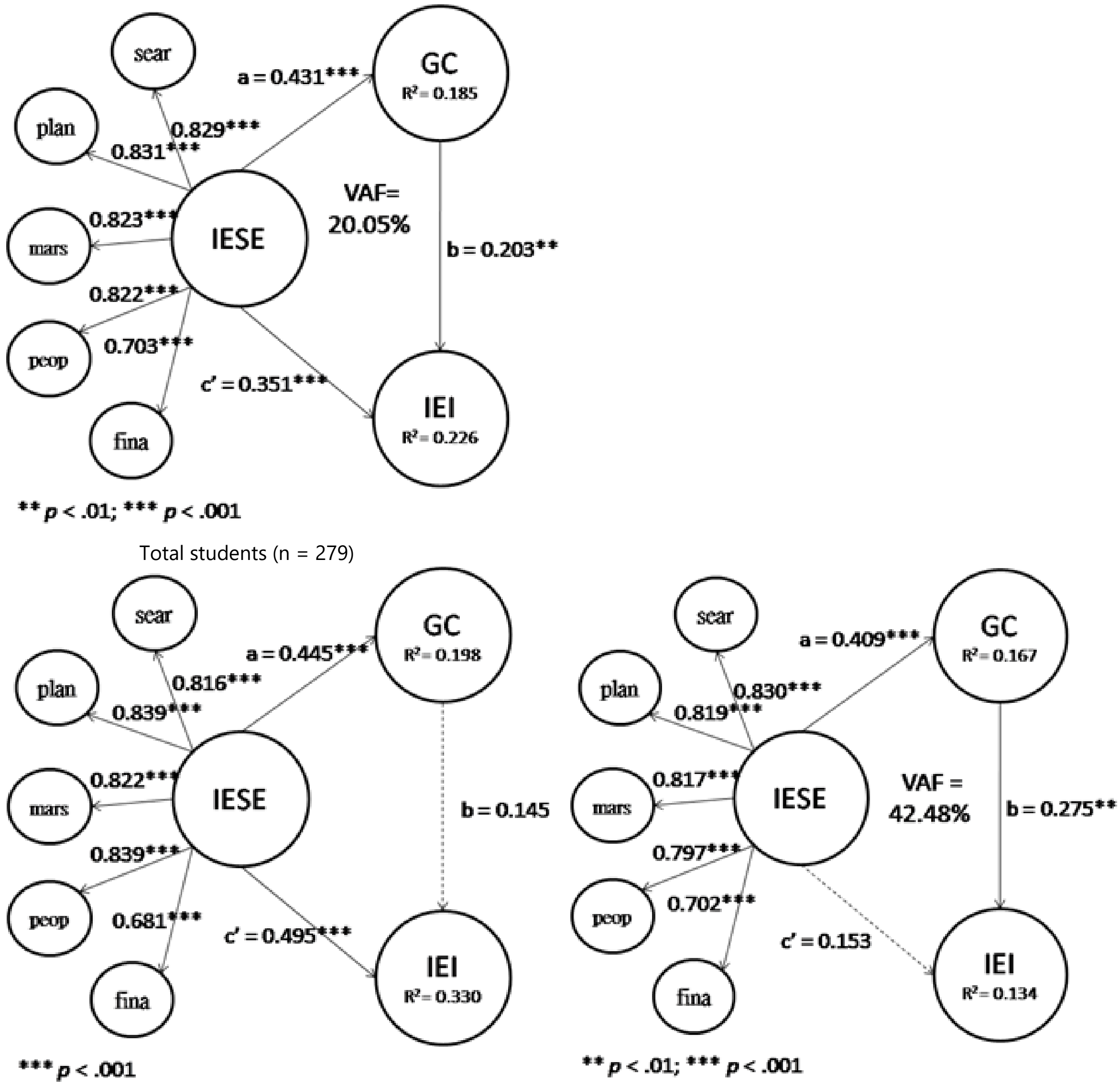
Table 6. The Analysis of Mediation

		Total (n = 279)			PERMs (n = 146)			NERMs (n = 133)			Difference between Coefficient		
Path		**Coeff.**	***t-value***		**Coeff.**	***t-value***		**Coeff.**	***t-value***		**Diff.**	***pHenseler***	
Direct Effects													
CESE→GC	a	0.431	7.590	***	0.445	5.815	***	0.409	4.950	***	0.036	0.377	ns
GC→CEI	b	0.203	3.215	**	0.145	1.904	ns	0.275	2.808	**	-0.131	0.853	ns
CESE→CEI	c′	0.351	5.138	***	0.495	6.636	***	0.153	1.439	ns	0.342	0.005	**
Indirect Effects													
CESE→GC→CEI	a*b	0.088	2.930	**	0.064	1.724	ns	0.113	2.469	*	-0.048	0.794	ns
Percentile bootstrap 95% CI		[0.034,	0.153]		[-0.003,	0.142]		[0.035,	0.210]				
Total Effects													
CESE→CEI	c = a*b+c′	0.439	7.518	***	0.560	8.873	***	0.266	2.798	**	0.294	0.004	**
Mediation Effects													
VAF (Variance account of)													
a*b/(a*b+c′)*100%		20.05%			11.45%			42.48%					

Notes. PERMs = presence of entrepreneurial role models; NERMs = no entrepreneurial role models; CESE = cyber-entrepreneurial self-efficacy; GC = goal commitment; CEI = cyber-entrepreneurial intentions.
*p < 0.05; **p < 0.01; ***p < 0.001 (two-tail t distribution). ns = not significant.

Parameter estimation was conducted for the comparison of the two groups. The standard errors and parameters of the resamples were used to calculate the t-values to determine whether there were significant differences in the coefficients of the paths between the groups. This was done in case our data were distributed normally and/or the variances of the two groups were not too different from each other (tParam {EV}). A Welch-Satterthwait test – tParam {NEV} was also done in case the variances between the two were very different (Sarstedt, Henseler, & Ringle, 2011). The results of the two tests were similar: Indirect Effects CESE→CEI – tParam {EV} = 2.676 (p < 0.01), tParam {NEV} = 2.639 (p < 0.01); Total effects CESE→CEI – tParam {EV} = 2.628 (p < 0.01), tParam {NEV} = 2.586 (p

< 0.05). The R-squared values were as follows: PERMs – CESE→GC (19.8%), CESE→GC→CEI (33.0%); NERMs – CESE→GC (16.7%), CESE→GC→CEI (13.4%). Significant differences were detected in all (See **Figure 2**).



Total students (n = 279)

PERMs (*n* = 146)

NERMs (*n* = 133)

Figure 2. Results of Structural Model Analysis

Hypotheses testing for the mediation effects

Hypothesis 4 investigated the mediating role of goal commitment (GC), with student's CESE as the independent variable (X), CEI as the dependent variable (Y), and GC as the mediator variable (M). The mediating effects of PERMs and NERMs were analyzed using the multi-group analysis (MGA). Sequential testing was conducted according to the suggestions offered by Hair et al. (2014) on mediation analysis: (1) X significantly predicts Y; (2) X significantly predicts M and M significantly predicts Y; (3) X and M both significantly predict Y.

We examined the mediation model through the assessment of the variance accounted for (VAF): VAF > 80% indicated full mediation; 20% ≤ VAF ≤ 80% indicated partial mediation; VAF < 20% indicated no mediation. Data were analyzed with SmartPLS 3.0 to see whether they supported our hypotheses. PLS-MGA was conducted to determine whether there was a significant difference between the path coefficients of the PERMs and NERMs.

The path coefficients, t-statistics, and their significance are shown in **Table 6**. According to the data of the total sample (n = 279), CESE (X) positively predicted CEI (Y) (c = 0.439, p < 0.001), indicating that H1 was supported;

CESE (X) positively predicted GC (M) (a = 0.431, $p < 0.001$), indicating that H2 was supported; and GC (M) positively predicted CEI (Y) (b = 0.203, $p < 0.01$), indicating that H3 was also supported. The mediation analysis revealed that the indirect effect of CESE (X) on CEI (Y) (a*b = 0.088, $p < 0.01$, 95% CI [0.034, 0.153]) was smaller than the direct effect of CESE (X) on CEI (Y) (c′ = 0.351, $p < 0.001$); VAF-value was 0.201 (20% ≤ VAF ≤ 80%), indicative of partial mediation. This shows that in the causal relationship of CESE (X) and CEI (Y), GC (M) exhibited the effect of partial mediation; H4 was thereby supported. The results of the hypotheses testing are illustrated in **Figure 2**. For the effect of students' CESE (X) on their GC (M), the explanatory power was 18.5% ($R^2 = 0.185$); for the effect of students' CESE (X) on their CEI (Y) via the mediation of their GC (M) , the explanatory power was 22.62% ($R^2 = 0.226$).

According to the data of the PERMs (n =146), CESE (X) positively predicted CEI (Y) (c = 0.560, $p < 0.001$), indicating that H1 was supported; CESE (X) positively predicted GC (M) (a = 0.445, $p < 0.001$), indicating that H2 was also supported; GC (M), however, failed to significantly predict CEI (Y) (b = 0.145, $p > 0.05$), H3 was therefore not supported. Because M failed to significantly predict Y, our model did not fit the sequence of mediation analysis proposed by Hair et al. (2014); therefore there was no mediation, and H4 was not supported (See **Figure 2**).

According to the data of the NERMs (n = 133), CESE (X) positively predicted CEI (Y) (c = 0.266, $p < 0.01$), indicating that H1 was supported; CESE (X) positively predicted GC (M) (a = 0.409, $p < 0.001$, indicating that H2 was supported; and GC (M) positively predicted CEI (Y) (b = 0.275, $p < 0.01$), indicating that H3 was also supported. The mediation analysis revealed that the indirect effect of CESE (X) on CEI (Y) (a*b = 0.113, $p < 0.05$, 95% CI [0.035, 0.210]) was smaller than the direct effect of CESE (X) on CEI (Y) (c′ = 0.153, $p > 0.05$); VAF-value was 0.425 (20% ≤ VAF ≤ 80%), indicative of partial mediation. This shows that in the causal relationship of CESE (X) and CEI (Y), GC (M) exhibited the effect of partial mediation; H4 was thereby supported. For the effect of students' CESE (X) on their GC (M), the explanatory power was 16.7% ($R^2 = 0.167$); for the effect of students' CESE (X) on their CEI (Y) via the mediation of their GC (M) , the explanatory power was 13.4% ($R^2 = 0.134$) (See **Figure 2**).

DISCUSSION AND IMPLICATIONS

The present study investigated the mediation effect of GC on the relationship between CESE and CEI in the context of undergraduate entrepreneurship education. We hope to add to the literature of cyber entrepreneurship education and contribute to the further development of this field. The discussion and implications of our study are as follows.

Cyber-entrepreneurial Self-efficacy has a Direct Positive Effect on Cyber-entrepreneurial Intentions

The results of the analyses revealed that students' CESE has a direct positive effect on their CEI in the context of cyber entrepreneurship education. Such finding is correspondent with the results of previous research (Barbosa et al., 2007; BarNir et al., 2011; Carr & Sequeira, 2007; Kickul et al., 2009; Liñán, 2008; Piperopoulos & Dimov, 2015; Sesen, 2013; Trevelyan, 2011; Zhao et al., 2005). As social cognitive theory claims, no mechanism of personal agency is more central or pervasive than beliefs of self-efficacy (Bandura, 1989). Any factor that may serve as a guide or a motivator is rooted in the core belief that one's actions can lead to desired effects; otherwise, one would have little or no incentive to act or persevere in the face of difficulties (Bandura, 2002). Studies have found that when subjected to equally painful events, those who are led to believe that they have personal control over the events display lower autonomic arousal and less performance impairment than those who believe the opposite (Geer, Davison, & Gatchel, 1970; Glass et al., 1973). It is therefore important for teachers and researchers of cyber entrepreneurship education to find out how to enhance CESE in students.

Cyber-entrepreneurial Self-efficacy has a Direct Positive Effect on Goal Commitment

The results of our analyses indicated that students' CESE has a direct positive effect on their GC, which conforms to the findings of previous studies (Baum & Locke, 2004; Locke et al., 1984; Locke & Latham, 2002, 2006; Wu, 2002). Bouffard-Bouchard (1990) experimentally induced high and low self-efficacy perceptions in college students with equivalent knowledge and experience in a performance domain, and found out that students with fictitiously induced high self-efficacy set higher goals for themselves, used more efficient problem-solving strategies, and achieved higher intellectual performances than did students with induced low self-efficacy. This proved the effect of perceived self-efficacy on goal setting and aspiration (Bandura & Locke, 2003; Geldhof et al., 2014; Wood & Bandura, 1989). Our finding is consistent with the belief in social cognitive theory that ESE is an important factor that improves GC (Bandura & Locke, 2003; Lock & Latham, 2002).

The Mediation Effect of Goal Commitment

People are aspiring and proactive beings, who motivate and guide themselves by setting personal goals and performance standards, and then invest energy and resources to achieve them (Bandura & Locke, 2003). Przepiorka (2016) identified the differences between entrepreneurs and non-entrepreneurs with respect to goal-commitment (effort, persistence, goal satisfaction) and found out that entrepreneurs with greater goal-commitment (who put in more effort and were more persistent and satisfied with their goals) during the prelaunch phase of the entrepreneurial process had greater intention to succeed.

Other studies have also found that GC has an indirect effect between self-efficacy and learning performance (Chu & Peng, 2009). In the current study, partial mediation effect of GC was observed between the CESE and CEI of Total Students and NERMs; furthermore, such effect was greater in NERMs than in Total Students. These results are in accordance with the findings of earlier research (Geldhof et al., 2014; Schmitt-Rodermund, 2004).

Comparison of Categorical Effects of PERMs and NERMs

Role models have long been suggested to have a profound influence on career decisions (Krumboltz, Mitchell, & Jones, 1976). ERMs have been shown to enhance ESE and EI (Boyd & Vozikis, 1994; Fayolle, Gailly, & Lassas-Clerc, 2006). In the present study, we found that the presence of entrepreneurial role models made a significant difference to the effect of students' CESE on their CEIs, but not so much to the relationships between their CESE and GC and their GC and CEI. Interestingly, the partial mediation effect of GC was only found between the CESE and CEIs of the NERMs and not those of the PERMs. One probable explanation is that ERMs lead by example, so that in their presence, the students can foresee their own future as an internet entrepreneur fairly clearly and know fairly well what such a career entails through their observations of the ERMs.

Consequently, the degree of such students' GC cannot have as much impact on their CEIs as the GC of NERMs would on theirs. Without the presence of ERMs, the NERMs will probably need a much higher degree of GC in order to have the courage and motivation to generate a genuine CEI. Fayolle et al. (2006) have stated that EI becomes stronger when self-efficacy is enhanced by the presence of ERMs. St-Jean and Mathieu (2015), however, observed that mentoring appears to have a direct negative effect on the intension (to stay in the profession) of novice entrepreneurs; and suggested that mentoring should come earlier in the entrepreneurial process.

Our study seems to support their claims. In terms education, Fayolle et al. (2006) found that the entrepreneurship education programs they tested had a significant impact on the EI of the students. Piperopoulos and Dimov (2015) discovered that among the students taking theoretically-oriented entrepreneurship courses, higher self-efficacy is associated with lower EIs; and among the ones taking practically-oriented entrepreneurship courses, higher self-efficacy is associated with higher EIs. The findings of the current study seem to suggest that the students with PERMs developed more ambitious EIs under the positive influence of their ERMs. For those with NERMs, such EIs may need to be developed more indirectly.

CONCLUSION

Our research aims to integrate the concepts of social cognition theory and goal-setting theory in an investigation of the effects of CESE and GC on CEIs in the context of undergraduate entrepreneurship education. The results showed that students' CESE has a positive effect on their GC and CEIs individually, and that their GC also has a positive effect on their CEIs. However, we found that GC only has a partial mediation effect between CESE and CEIs in NERMs but not in PERMs. These results have important implications for the practice and research of higher entrepreneurship education. It means that cyber-entrepreneurship educators and practitioners will be able have a better understanding of the students' CESE through their levels of GC, and come up with better methods or designs for the entrepreneurial curricula that will better promote students' CEIs. Our findings also suggest that when designing the curriculum, entrepreneurship educators should take into consideration the different effects the presence/absence of ERMs might have on the CEIs of students.

Based on the findings of prior research and this study, we propose the following recommendations for schools that offer entrepreneurship education: (1) invite entrepreneurs to serve as mentors/coaches for university students of NERMs, because they could learn the practical cyber entrepreneurship from the interaction with mentors or coaches to cultivate CESE and GC. Moreover, media role models and mentoring are proved to effectively motivate and guided students by foresight of goals (risk control), not just by hindsight of shortfalls (fear of risk or failure). (2) offer innovative interdisciplinary courses or integrated curricula (e.g. The remote role model-theme case study) to integrate the knowledge and practice. (3) establish open-loop university (Cheng, 2016) to allow and encourage potential/aspiring entrepreneurs or students to return to school whenever they desire or feel the need to. (4) create a virtual community with entrepreneurship and innovative atmosphere for potential/aspiring entrepreneurs and experienced ones to continually enhance their CESE and GC by exchanging their knowledge and experiences. (5)

bring all courses together on a common "learning and application platform" that is fully linked and collaborative with external networks such as those of the government agencies and business organizations. Such platform can help students form a clearer concept of entrepreneurial career intentions, and enhance their CESE and GC before they reach their entrepreneurial goals.

Although we strove to conduct the entire research in the most rigorous manner, some limitations and flaws nevertheless existed; we hereby acknowledge them. First, in terms of the participants, we have surveyed only the undergraduate students in Taiwan majored mostly in business management or STEM. Therefore, the generalizability of our results might be somewhat limited. Secondly, in terms of the variables, even though we have proven that students' GC partially mediates the relationship between their CESE and CEIs, the total variance explained was low. This means that besides CESE and GC, there may be other factors such as perceived collective efficacy (Prussia & Kinicki, 1996) affecting the level of students' CEIs. In light of the aforementioned limitations, we suggest that future research may survey students from more diverse academic backgrounds and ethnicity, and in different stages of learning to improve generalizability. Future researchers may also want to include more variables in their study to more extensively explore the factors influencing students' CEIs.

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The Curriculum Ideology Recommended by Novice Teachers for Life Sciences in South Africa

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ABSTRACT

South African has adopted the Curriculum and Assessment Policy Statement curriculum, which is aimed at promoting citizenship education. However, the extent to which teachers subscribe to the same ideology has yet to be investigated. The current study explored the curriculum ideology recommended by teachers in Life Sciences, in order to determine the extent to which they support citizenship education. Participants were postgraduate teachers employed in various government schools in Gauteng, South Africa. A semi-structured questionnaire was used for data collection. Results show that teachers recommended multiple ideologies with greater support for the student-centred and service-centred ideologies. The citizenship-centred ideology was least recommended. These findings suggest that citizenship education may not be realized, as teachers do not recommend the relevant ideology.

Keywords: curriculum ideologies, curriculum reforms, Life Sciences, teachers

INTRODUCTION

Gagne (1967, p. 23) defines a curriculum as a “sequence of content units arranged in such a way that the learning of each unit may be accomplished as a single act, provided the capabilities described by specified prior units (in the sequence) have already been mastered by the student”. Similarly, Popham and Baker (1970) define a curriculum as the planned learning outcomes for which the school is responsible. Taylor (1957, p. 79) however defines a curriculum as “all the learning experiences planned and directed by the school to attain its educational goals”. In the current study, these and other definitions of a curriculum are combined and a curriculum is defined as the documented outline of predetermined learning outcomes, subject matter and sequence of learning experiences developed by educational authorities (Mnguni, 2013).

Educational authorities around the world regularly engage in curriculum review processes in order to respond to global and local emerging research, socio-economic and political dynamics. These include translation of the new ideas into new educational practices (Pietarinen, Pyhältö & Soini, 2017), standardizing content and learning outcomes (Porter, Fusarelli & Fusarelli, 2015), renewing educational content and experiences (Huang, 2004) as well as introducing student-centred curricula, content and pedagogies (Bulut, 2007). In South Africa, the government has imposed the Curriculum and Assessment Policy Statement (CAPS), which specifies the purposes of learning, the content to be taught as well as the assessment procedures to be followed (Spaull, 2013). As part of this, the CAPS curriculum has introduce citizenship education values to ensure that students, and the society, become selfless, clear-thinking and enlightened citizens who participate in the reconstruction and empowerment of the society (Waghid, 2002).

Since 1994, South Africa has had three curriculum revisions, which led to the adoption of the National Curriculum Statement (NCS) in 2002 and the current CAPS curricula which has been followed since 2012 (Chisholm, 2003; du Plessis, 2013; Jansen, 1998; Msila, 2007). The underlying socio-political premise for these reforms was the promotion of citizenship education as can be understood from Nelson Mandela’s view that education is the tool that can be used to change the world (Mandela, 2003). In this regard, curriculum reforms in South Africa are generally aimed at “redressing the inequalities and injustices caused by the apartheid regime policies, using education as its tool” (Bantwini, 2010, p. 84). As such, the objective of these curriculum reforms range

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Contribution of this paper to the literature

- The current research explored the curriculum ideology recommended by novice teachers for Life Sciences.
- Teachers recommended the student-centred and service-centred ideologies.
- The citizenship-centred ideology which supports citizenship education was least recommended. As a result, citizenship education envisage in the Life Sciences curriculum may not be realized.

from cleansing syllabi of racist language and controversial and outdated content, to the introduction of content and pedagogy which promotes social justice as defined in the Constitution of the Republic of South Africa (du Plessis, 2013; Van Deventer, 2009). However, regardless of these curriculum reforms, poor student performance and a number of socio-scientific challenges remain well founded as evidenced in the recent so-called #*FeesMustFall* university student protests (Luescher, Loader & Mugume, 2017). In these protests, students and academics called amongst other things for the decolonization and Africanization of the curriculum by teaching context-specific content knowledge (Le Grange, 2016). This is because researchers, students and members of the society in general have identified a lack of curriculum relevance as related to the poor implementation of curriculum reforms (Stuckey, Hofstein, Mamlok-Naaman & Eilks, 2013). What is not well documented however are the ideological impediments that hinder the effective implementation of the curriculum reforms.

Role of Teachers in Curriculum Reform

Alsubaie (2016) argues that teachers are the most important people in the implementation of curriculum reforms. Teachers are viewed as significant agents of curriculum change and their preparedness to adopt curriculum reforms is crucial in shaping the success or failure of curriculum change (Lee, Yin, Zhang & Jin, 2011). As such, it is imperative that teachers be intrinsically involved in curriculum development. If not, then teachers are burdened with the need to learn the curriculum and adjust their preferred curriculum ideologies, teaching philosophies and methods to suit the needs of the new curriculum. In these instances, teachers may be confronted with circumstances that limit their effectiveness, which may lead to regular and harsh public criticism due to poor student performance (Eacute & Esteve, 2000).

Another key factor in the success of implementing curriculum reform is teacher preparedness to adopt new curriculum ideologies, new content and new ways of teaching as may be required in the reformed curriculum (Lee & Yin, 2005). Sadly, however, there is evidence that teachers are not always empowered to implement curriculum reforms (Alsubaie, 2016). Pre-service and in-service teacher-training programmes tend to focus only on pedagogical content knowledge rather than curriculum theory including ideologies that inform curricula (Mnguni, 2013; Sweetland & Hoy 2000). Kelchtermans (2005) also argues that underlying teaching philosophies, teachers' emotions and normative beliefs, which are grounded on structural condition of the teaching job, are often ignored in curriculum reformation. This is in line with Ajzen (1991), who argues that behaviour such as teaching is associated with normative beliefs. Consequently, if curriculum reforms impose different normative beliefs they may trigger intense resistance (Bantwini & King-McKenzie, 2011). It is for this reason that the current researcher explores teachers' recommended curriculum ideology in order to determine possible areas of conflict between teachers and the curriculum. A curriculum ideology refers to,

> *"the overarching aims or purposes of education, the nature of the child or student, the way learning must take place, the role of the teacher during instruction, the most important kind of knowledge that the curriculum is concerned with and the nature of this kind of knowledge, and the nature of assessment" (Schiro, 2008: 7).*

Of significance in the current research is not teacher preparedness to implement a curriculum as this has been exhaustively explored (e.g. Ramatlapana & Makonye, 2012). Instead, the researcher was more interested in determining whether teachers' recommended curriculum ideologies would support citizenship education. This is because Goodlad and associates (1979) suggest that there are at least five different levels of a curriculum, namely, the ideological, formal, perceived, operational and the experienced levels of the curriculum. As such, curriculum reforms at any one level are not guaranteed to be transferred to another. In fact Kurz, Elliott, Wehby and Smithson (2010) show that there are instances where the intended, planned and enacted curricula are not aligned leading to poor implementation of curriculum reforms. Other researchers (e.g. Bantwini, 2010; Mnguni, 2017) have also shown that differing ideologies may trigger misinterpretations and alternative interpretations during the translation of the curriculum through the different levels. One wonders therefore whether teachers share the same curriculum ideologies with the curriculum.

Table 1. A comparison of curriculum ideologies (adapted from Schiro, 2008)

Curriculum features		Discipline-centred ideology	Service-centred ideology	Student-centred ideology	Citizenship-centred ideology
Aim of the subject	Purpose for knowledge	Understanding	Doing / action	Actualizing oneself	Interpret and reconstruct society
Content knowledge	Nature of knowledge	Didactic statements	Capabilities for action	Personal meanings	Intelligence and a moral stance
	Source of knowledge	Objective reality as interpreted by academic disciplines	Normative objective reality as socially interpreted	Individuals' personal creative response to experience	Individuals' interpretation of society's past, present and future
Instructional Process	Learning viewed from	Transmitter	Transmitter	Receiver	Transmitter
	Primary function of learning	Social transmission	Social transmission	Growth	Social transmission
	Result of learning	Changed mindset	Changed behaviour	Changed mindset	Changed behaviour
	Primary actor during learning	Agent	Agent/student	Student	Agent/student
	Student readiness	Simplification of difficult topics	Providing prerequisite behavioural capabilities	Stages of growth	Gestalt of prior experience
The student	Role during learning	Passive	Active	Active	Active
	Teachers focuses on	Student's mind	Student's behaviour	Student's mind	Student's behaviour
	Teachers concerned with children	As they ought to be	As they ought to be	As they are	As they ought to be
	Viewing children	In relation to standardized norms	In relation to standardized norms	As individuals	In relation to standardized norms
Teaching	Role of teacher	Transmitter	Supervisor	Facilitator	Colleague
	Standards used to measure teacher effectiveness	Accurate presentation of discipline	Efficiency of student learning	Facilitation of growth	Effective transference of the vision
	Teachers stimulate	Uniformity	Uniformity	Diversity	Uniformity
	Teachers	Directly implement curriculum	Directly implement curriculum	Adapt curriculum (according to children's needs)	Adapt curriculum (according to social concerns)
	Media used during learning	Didactic discourse	Programmed instruction	Child-environment interaction	Group dynamics
	Intent of teaching	To advance students in a discipline	To prepare students to perform skills	To stimulate child growth	To acculturate students into educators' vision
Assessment	Purpose of evaluation to the evaluator	Rank students for a future in the discipline	Certify that students have the skills	Diagnose students' abilities to facilitate growth	Measure student progress with respect to ability
	Nature of assessment tools	Norm reinforced	Criterion reinforced	Informal subjective diagnosis	Informal subjective diagnosis
	Assessments are	Objective	Objective	Subjective	Subjective
	Point of assessment	After instruction	After instruction	During instruction	During instruction

Theoretical Framework of the Research

The current research adopted Schiro's (2008) curriculum ideologies as a framework (**Table 1**). This is because Schiro (2008) provides a condensed summary of ideologies based on various curriculum ideologies documented in literature. He shows that there are at least four ideologies. These are defined here as discipline-centred ideology, service-centred ideology, student-centred ideology and citizenship-centred ideology. Each ideology is based on the view that there are six components of the curriculum through which a curriculum ideology could be understood. These are the purpose of the subject, the nature of knowledge, the instructional process (including teaching and learning), the role of the teachers, the role of the students and the assessment.

The primary objective of the discipline-centred ideology is transmitting discipline-specific knowledge, by teaching students epistemological and ontological principles of the discipline (Schiro, 2008). This is done to preserve the autonomy of academic disciplines and the associated knowledge (Cotti & Schiro, 2004; Ravitch, 2000; Schiro, 2008). The curriculum in this ideology is regarded as unchallengeable high ground and impregnable fortresses that is immune to the effects of curriculum reform and socio-political dynamics (Goodson, 1992; Kliebard, 2004; Venville, Wallace, Rennie & Malone, 2002).

The service-centred ideology shifts the focus from the discipline to the society, particularly the services that the graduate must offer (Schiro, 2008). In this ideology therefore, faculty is responsible for identifying societal problems and then develop learning programmes that will help students develop necessary skills required in providing services to the society. The learning programmes therefore are systematically derived from a particular role, or task, considered important to do a particular job (Abbatt & McMahon, 1993). Curriculum designers in this regard identify and transform knowledge and skills into learning objectives, which in turn are arranged into learning experiences.

In the student-centred ideology, teaching and learning is focused on the student, his interests and abilities and students are allowed to construct their own knowledge and develop skills (Schiro, 2008). Teaching therefore is a nurturing process where teachers are facilitators and mentors. The student-centred ideology is founded on the idea that "artisans learn to forge by forging, to carve by carving, to paint by painting...let children learn to write by writing, to sing by singing, and to reason by reasoning" (Schiro, 2008, p. 112). It is based on the notion that students' natural abilities and interests should be central to teaching to facilitate the growth of students by helping them develop their skills and abilities further.

Citizenship-centred ideology is seen as the ideology that supports principles of citizenship education (Mnguni, 2017). In this ideology, students are viewed as members of the community in which they live; who have the ability to influence and be influenced by the norms, values and practices of their societies through intelligence and knowledge (Cotti & Schiro, 2004). Central to a citizenship-centred ideology therefore is the view that students must acquire knowledge and skills that will enable them to identify social ills and be able to reconstruct these into social benefits. This however means teaching and learning must occur within community settings, rather than isolated school classrooms that are divorced from the community, so that everyday dynamics of the society are an integral part of the curriculum. It is this form of education that could foster citizenship (Mnguni, 2013).

Research has shown nonetheless that curriculum ideologies are only ideals (Mnguni, 2013). In reality, curricula tend to have a mélange of ideologies, slightly preferring one view over others in particular aspects (Mnguni, 2017; Kliebard, 2004). What is important however is that curriculum designers and teachers have an understanding of the founding curriculum theory of their respective curriculum and minimize confusion in terms of their curriculum and instructional design, confusion that may lead to teaching and learning difficulties.

Aim of the Research

Emanating from the above discourse, the aim of the current research was to investigate the curriculum ideology recommended by South African novice teachers in Life Sciences, in order to determine the extent to which they support citizenship education. The research question in this regard was:

Which curriculum ideology do novice teachers recommend should inform Life Sciences?

A response to this question would be significant to teacher-training institutions and curriculum designers, as it would demonstrate possible discrepancies between teachers' recommended ideology and the curriculum intentions, which may compromise the effective implementation of the curriculum thereby compromising the realization of its intentions.

METHODOLOGY

Research Design

In pursuing the current research, the researcher adopted a multiplistic realism research paradigm. This paradigm was selected because of its flexibility in accommodating mixed-methods and multiplistic epistemologies (Krauss, 2005). As a result, the researcher followed the explanatory concurrent mixed-method approach for data collection where the open-ended qualitative data were used to explain the closed-ended quantitative data.

Sampling

Concerning selecting participant, the researcher followed a non-probability convenience sampling approach to select forty-two novice Life Sciences teachers, who were part-time Bachelor of Education Honours students majoring in Science Education, with particular interest in Biology Education. Life Sciences is a school subject, previously known as biology, which is taught in Grades 10 to 12. The participants had completed a Bachelor's degree in Education in the previous two years. In the undergraduate programme all participants were exposed to the structure and contents of the CAPS Life Sciences (Department of Basic Education 2011). This included reading through the curriculum documents, preparing lesson plans guided by the CAPS Life Sciences as well as implementing aspects of the curriculum during teaching practice. They had all passed related examinations. Thirty-six percent (36%) of the participants identified themselves as male, while 66% identified as female. Forty three percent (43%) of the participants were working in well-resourced schools, while 57% were from under-resourced schools. All participants were either in their first or second year of work as Life Sciences teachers in government schools in Gauteng in which the CAPS Life Sciences curriculum was mandatory. These relatively novice teachers were selected in order to determine their recommendations based solely on theoretical knowledge rather than extensive experience. Further research is being carried out to determine experienced teachers recommendations. Participation in the research was voluntary and carried no incentives to the participants. The research was granted ethical clearance by the university in which it was carried out (Ethical Clearance Number: 2015-066).

Data Collection

During the research, participants were first given two one hour lectures on curriculum ideologies by the researcher who is a science education curriculum specialist, based on Schiro's (2008) and Mnguni's (2013) research on curriculum ideologies. This was to provide participants with an understanding of the concept of curriculum ideology as well as the different types of curriculum ideologies. No content knowledge assessment was conducted following these lectures. A week after the lectures, the participants were indirectly asked to recommend the curriculum ideology that should inform the purpose of the Life Sciences, the nature of knowledge in Life Sciences, the instructional process (including teaching and learning), the role of the teachers, the role of the students and the assessment in Life Sciences and ultimately the subject itself. To do this, participants were asked to respond to a semi-structured questionnaire, which was made up of six questions. Each question represented the six components of the curriculum (Schiro, 2008; Mnguni, 2013). Within each were four statements summarizing each curriculum ideology in no particular order. These statements were adapted from Schiro's (2008) standard inventory for curriculum analysis aimed at determining a curriculum ideology. Participants were therefore asked to rank these statements in the order of what they perceived, based on their training should be the primary focus in Life Sciences. Participants were not told that the statements were representing the ideologies. They were however asked to explain their ranking of the statements. A panel of three independent science education curriculum experts who confirmed content and face validity evaluated the questionnaires used in the research. The questionnaire was also piloted on a group of final year Bachelor of Education students where reliability was tested. The reliability coefficient in this regard was .78.

Data Analysis

For example, one question asked the participants to read statements a – d below carefully and then rank the statements from 1 to 4, placing:

1 - next to the statement that they recommend should be the first priority of Life Sciences

2- next to the statement that they recommend should be the second priority of Life Sciences

3- next to the statement that they recommend should be the third priority of Life Sciences

4- next to the statement that they recommend should be the fourth priority of Life Sciences

Participants were allowed to place the same priority on different statements where they thought it was necessary.

a) The purpose of Life Sciences should be to provide an enjoyable, stimulating, students-centred environment organized around the developmental needs and interests of students as those needs and interests present themselves from day to day.
b) The purpose of Life Sciences should be to provide students with the ability to perceive problems in society, envision a better society, and act to change society so that there is social justice and a better life for all people.
c) The purpose of Life Sciences should be to provide should be the creation of communities where the accumulated knowledge of the culture is transmitted to the students.
d) The purpose of Life Sciences should be to provide should be the fulfillment of the needs of society by efficiently training students to function as mature constructive members of society

While the above statements have overlaps between the different ideologies, each one of them predominantly reflects the principles of a specific curriculum ideology (see **Table 1**, Schiro, 2008). Statement a) to d) above reflected a predominantly student-centred ideology, citizenship-centred ideology, discipline centred ideology and service-centred ideology respectively. The responses were then quantified descriptively to determine the ranking patters of the different ideologies amongst the participants.

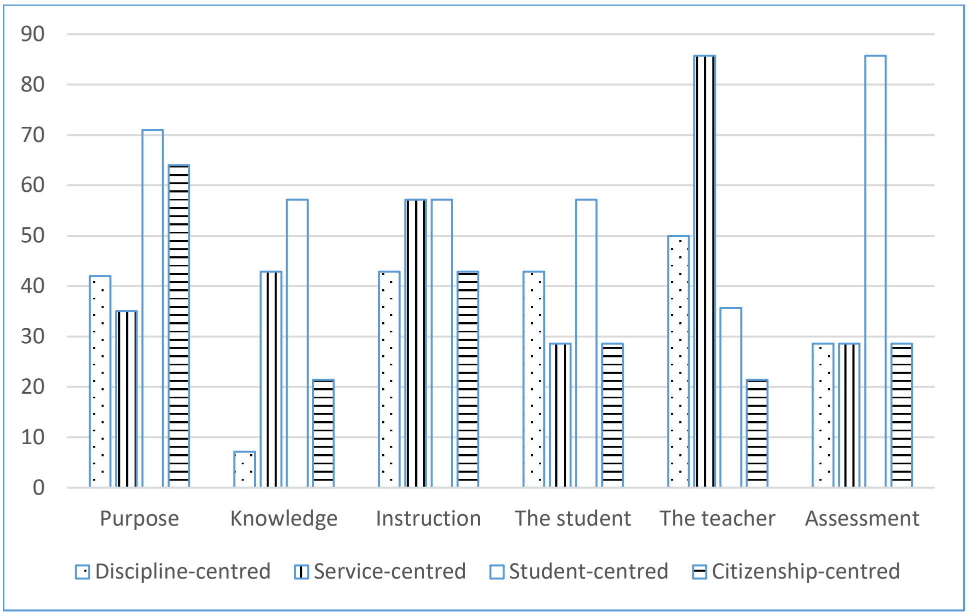

Figure 1. Participants' recommended ideology for Life Sciences

RESULTS OF RESEARCH

The percentage scores presented below are non-cumulative given the fact that respondents were asked to rank the statements in order of their recommendation, where some statements were ranked equally.

Results (**Figure 1**) show that the most recommended curriculum ideology amongst the participants was the student-centred ideology (61%), followed by service-centred (46%). The citizenship-centred ideology was least recommended with only 34% of the participants supporting it. The student-centred ideology was recommended by over 50% of the participants in five of the six components of the curriculum (see **Figure 1**). In fact, the student-centred ideology received the lowest score only in the instructional process, where it was recommended third. The citizenship-centred ideology was the least recommended, by less than 30% of the participants in four of the six components of the curriculum. It however received the second highest recommendation in the purpose of the subject.

Statistical analysis of the data showed that gender does not correlate with the recommended curriculum ideology as well as between the type of school (well-resourced and under-resourced) and the recommended curriculum ideology ($p > .001$).

Purpose of Life Sciences

Looking at the purpose of the subject, results show that the student-centred ideology was the most recommended amongst the participants (ranked first by 71% of the participants) while service-centred was least recommended. Most participants (71%) indicated that "Life Sciences classrooms should be an enjoyable, stimulating, students-centred environment organized around the developmental needs and interests of students as those needs and interests present themselves from day to day". The citizenship-centred ideology received the second most recommendation with 64% of the participants suggesting that "Life Sciences should provide students with the ability to perceive problems in society, envision a better society, and act to change society so that there is social justice and a better life for all people."

Nature of Knowledge

Regarding the nature of knowledge, participants' recommendation was in line with the student-centred ideology. Here 57% of the participants indicated that "the knowledge of most worth is the personal meaning of oneself and of one's world that comes from one's direct experience in the world and one's personal response to such experience." The participants least recommended the discipline-centred ideology with only 7% indicating that "the knowledge of most worth is the structured knowledge and ways of thinking that have come to be valued by the culture over time".

Instructional Process

There was no clear stand-out ideology recommended for the instructional process. For example, both the service-centred and student-centred ideologies were recommended by 57% of the participants, while both discipline-centred and citizenship-centred ideologies were recommended by 43% of the participants. Concerning service-centred, the participants indicated that "learning best proceeds when the student is presented with the appropriate stimulus materials and positive reinforcement." They also indicated that "learning best takes place when students are motivated to actively engage in experiences that allow them to create their own knowledge and understanding of the world in which they live" which is indicative of the student-centred ideology.

Role of the Student

Asked about the role of students during learning, most participants (57%) indicated that "studentship is essentially a time when students unfold according to their own innate natures, felt needs, organic impulses, and internal timetables. The focus is on students as they are during childhood rather than as they might be as adults." This view was indicative of the student-centred ideology. Twenty nine percent (29%) of the participants indicated that learning "is essentially a time for practice in and preparation for acting upon society to improve both oneself and the nature of society." This is indicative of the citizenship-centred ideology.

Role of the Teacher

With regard to the role of the teacher, the majority of participates recommended the service-centred ideology (86%). Here the participants indicated that "teachers should be supervisors of learning, utilizing instructional strategies that will optimize student learning." Only a few participants (21%) were recommended the citizenship-centred ideology indicating that "teachers should be companions to students, using the environment within which the students lives to help the students learn." Similarly, the student-centred ideology was also recommended by few participants with only 36% saying, "Teachers should be aids to students, helping them learn by presenting them with experiences from which they can make meaning".

Assessment

Eighty six percent (86%) of the participants supported the student-centred ideology in relation to assessment. Participants in this regard indicated that "assessment should continuously diagnose students' needs and growth so that further growth can be promoted by appropriate adjustment of their learning environment. It is primarily for the students' benefit, not for comparing students with each other or measuring them against predetermined standards." All the other ideologies received a similar score of 28%.

DISCUSSION OF THE RESULTS

Researchers (e.g. Alsubaie, 2016; Lee, et al., 2011) have pointed out that teachers are significant agents of curriculum change and their preparedness to adopt curriculum reforms is crucial in shaping the success or failure of curriculum change. This preparedness is improved through teacher training as suggested by Lee and Yin (2005). In light of this, the major finding of the current research was that most participating teachers recommended the student-centred ideology and service-centred ideology for Life Sciences. The majority of the teachers did not recommend the discipline-centred and citizenship-centred ideologies. According to Mnguni (2013) and Mnguni (2017) the discipline-centred and student-centred ideologies are most reflected in the Life Sciences curriculum document. Apparently therefore, the student-centred ideology is the only ideology recommended by both teachers and the curriculum document. In the student-centred ideology, students are active participants during learning. This ideology supports the stimulation of growth and development of students (Posner, 1992; Schiro, 2008). In fact, knowledge itself is derived from students' personal and creative response to social and academic experiences. In the student-centred ideology, knowledge is viewed as students' personal meanings as constructed by students themselves (Schiro, 2008; Cotti & Schiro, 2004). What is emerging from these findings therefore is that teachers may not always recommend the curriculum ideology reflected in the curriculum. The extent to which this may affect curriculum implementation needs exploration.

The researcher argues however that an "ideological conflict" may emerge because aspects of the student-centred ideology (supported by teachers and the curriculum document) are somewhat direct opposite those of the discipline-centred ideology, which is adopted by the Life Sciences curriculum but not recommended by teachers. The manifestation of this ideological conflict may be through a resistance in the implementation of the curriculum among teachers (Bantwini & King-McKenzie, 2011) who may not support the discipline-centred ideology. This may be exacerbated by the fact that the curriculum reforms in South African were meant to promote citizenship education to ensure that students, and the society, become clear-thinking and enlightened citizens who participate in the reconstruction and empowerment of the society (Waghid, 2002). Yet as shown in the current and previous research (e.g. Mnguni, 2013), the Life Sciences curriculum and teachers do not recommend the citizenship-centred ideologies, which is fundamental to citizenship education. In the citizenship-centred ideology students are afforded an opportunity to interpret scientific knowledge within the context of their everyday life. By not recommending this ideology therefore, teachers may not integrate socio-scientific issues in their teaching, which are meant to bridge the gap between science and society. It is perhaps for this reason that Mnguni and Abrie (2012) as well as Mnguni, Abrie and Ebersöhn (2016) found that in Life Sciences students are taught HIV/AIDS knowledge as "academic knowledge" rather than "functional knowledge". As a result, students fail to apply this knowledge in their behavioural practices related to HIV/AIDS. The current researcher therefore posits that one of the reasons for this could be the apparent low support for the citizenship-centred ideology, which emphasizes the need to use lived experiences to teach scientific knowledge.

The current research also showed that the participating teachers recommended multiple ideologies. For example, teachers strongly support the service-centred ideology in the instruction process, but recommend the student-centred ideology for assessment. While it is probably impossible and not necessary for all teachers to adopt exclusively a single ideology (Mnguni, 2013), the researcher posits that the adoption of conflicting ideologies may be problematic. For example, interchanging ideologies in teaching and assessing may lead to learning difficulties for students, who are taught within one ideology and assessed in another.

CONCLUSION

The findings of the current research shed some light into the apparent resistance into the implementation of the curriculum in South Africa. The researcher suggests that this resistance could stem from ideological conflict between teachers and the curriculum on the purposes of education, the nature of the student, the way learning must take place, the role of the teacher during instruction, the nature of knowledge, and the nature of assessment. The researcher also argues that the lack of consistency in the recommended curriculum ideology among teachers may lead to added challenges regarding the implementation of new curricula. The researcher also concludes that the aspirations of the democratic South Africa to adopt citizenship education may not be realized due to minimal support for the citizenship-centred ideology.

While teacher-training programmes were not evaluated in the current research, the researcher believes that it is imperative that curriculum theory and curriculum design related to curriculum reforms must be addressed significantly. Further research is required however to determine possible links between conflicting ideologies and the implementation of the curriculum. Research is also required to determine the curriculum ideology of teachers, including experienced teacher, at a larger scale and across different school subjects.

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Misconceptions among Middle School Students Regarding the Conservation of Mass during Combustion

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ABSTRACT

This study focuses on the misconceptions of eighth-grade students in the Arab sector compared to the Jewish sector regarding the conservation of mass during combustion in a closed system and in an open system before the subject is taught, and to what extent the misconceptions change after it is taught. Students (N=195) from six heterogeneous classes were asked to fill in a ten-question questionnaire twice: once before the subject was taught and again afterwards. The findings indicated that students' understanding improved more with respect to closed systems compared with open systems; before the subject had been taught the situation was very similar for both cases. The students' explanations were based on visual arguments and showed that there was confusion concerning the effect of chemical, physical, and state of matter changes on the conservation of mass during combustion. Regarding the comparison between the conceptions of eighth-grade students in the Arab and Jewish (N=105) sectors, students in the Arab sector had better achievements in closed systems, whereas Jewish students gave more correct answers to questions in open systems. The study's findings can help middle-school students and their teachers understand that physical and chemical changes do not affect mass in a closed system, and that students should learn to distinguish between conservation of mass in open and in closed systems.

Keywords: chemical changes, combustion, mass conservation, misconceptions, physical changes

INTRODUCTION

Chemical reactions are one of the six basic concepts in chemistry and combustion is one of the most important oxidation-reduction reactions in general chemistry (Gillespie, 1997). Conservation of mass during combustion is a sub-topic in the study of chemical reactions, which is learned in middle school. The law of the conservation of mass is basic for our understanding of the world, and for understanding that energy is neither created nor disappears (Ochsendorf & Pyke, 2004, p.13). If one mixes a large quantity of different materials inside a closed system, the total mass is the same before and after the chemical reaction, irrespective of the amount of matter (even if the original materials are combined or separated). Middle-school students must therefore learn that physical and chemical changes in a closed system do not affect the amount of mass (Ochsendorf & Pyke, 2004). Piaget and Inhelder (1974) stressed that it is quite difficult for students to understand the concept of the conservation of mass in chemical reactions; in order to clarify the issue for them it is necessary to explain about volume, weight, and sometimes the density of matter. Stavy (1990a, 1990b, 1990c) maintains that if one uses colored gas, students find it easier to understand changes in matter than if the gas is colorless, because something invisible is perceived as mysterious. Ochsendorf and Pyke (2004) claim that in order to understand the conservation of mass, one must first understand the molecular structure of matter, that is, that matter consists of particles that undergo changes but they do not disappear.

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Contribution of this paper to the literature

- This study concentrates on misconceptions conservation of mass during combustion in a closed system and in an open system.
- Comparing misconceptions among eighth graders regarding the preservation of mass in combustion process between Arab and Jewish sectors in Israel who studying the same curriculum.
- Students' understanding improved more with respect to closed systems than with respect to open systems. Nevertheless, students in the Arab sector had better achievements in closed systems, whereas Jewish students had better achievements in open systems.

Misconceptions are generally defined as concepts structured inadequately or incorrectly by students, apart from concepts scientifically accepted as true, and that were acquired by students by the end of the educational process (Nakhleh, 1992). The main characteristics of misconceptions are that students construct alternative definitions for the concepts studied; many of them believe in them as scientific fact, and it is very hard to change such incorrect beliefs (Fisher, 1985). Moreover, misconceptions result from the student's attempts to understand their previous experiences resulting from their interaction with their environment and they must be taken into account in educational practice to design appropriate instructional strategies that will impulse their evolution into more scientific-academic concepts (Cañada et al., 2017). Barker and Millar (1999) found that students have difficulty understanding the conservation of mass and chemical reactions inside a closed system. For example, a piece of phosphorous was added to a bottle, which was then closed. The total mass was 400 g. The bottle was then exposed to sunshine and after a while, white smoke arose and was then dissolved in water. The students were then asked if the mass increased, decreased, or remained the same; thirty-seven percent replied that the mass had changed. Other studies also found misconceptions about the conservation of mass in chemical reactions (Ayas & Ozmen, 2003; Driver, Guesne, & Tiberghien, 1985; Nussbaum & Yehieli, 1995; Ochsendorf & Pyke, 2004) and in processes involving creating solutions (Andersson, 1984; Ochsendorf & Pyke, 2004). Hesse (2006) found that high-school students have difficulty in distinguishing physical from chemical changes and in explaining invisible processes (such as the release of gases). Students use made-up terms to explain various chemical reactions (Driver et al., 1985). When perfume is poured on a surface (an open system), it eventually evaporates (a physical change). Students explained that when matter becomes a gas it disappears, as do its atoms (Ochsendorf & Pyke, 2004). Eilks, Moellering and Valandies (2007) showed that students think that the material created in a chemical reaction consists of a mixture of materials. It is easier for them to explain phenomena at the macroscopic than at the microscopic level; they think that particles can be transformed into different ones in the same material.

Combustion is a chemical reaction involving oxygen and is accompanied by the emission of heat. Studies from around the world have shown that many middle- and high-school students cannot provide the correct chemical explanation for combustion and give erroneous answers, based on a lack of understanding the law of the conservation of mass (Boujaoude, 1991).

In a study in a middle school (N=20), students were asked to predict the change in mass when a candle burned in a closed system. Twelve students said there would be no change and eight said that the mass of the system would decrease (Boujaoue, 1991). In another experiment, students were asked about the mass of wood after it was burned. Some of them argued that the mass would be smaller, because the combustion products look smaller. On the other hand, when wood was burned to ash (in an open system) and students were asked why the mass decreased, some said that the number of atoms in the combustion products was smaller, and that therefore, the mass was less (Ochsendorf & Pyke, 2004). Interviews with the students revealed that they still held on to misconceptions after having been exposed to a number of experiments and examples. They used everyday words to describe chemical and physical changes, without giving a thought to their meaning as scientific terms (Boujaoue, 1991).

In a paper by Watson, Prieto, and Dillon (1995), the objective was to discover conceptions and misconceptions on combustion among students in England and Spain. Some of the students explained the chemical reactions without referring to the interaction between oxygen and the flammable material; their answers were based on the concept of "melting" – oxygen was not necessary for combustion and was metamorphosed by the fire. In Spain the method by which the subject was taught was that the teacher performed the experiment and explained it while the students listened and created knowledge, whereas in England it was the students who performed the experiment while the teacher explained the result. Despite the different teaching methods in the two countries, the study showed that students in both countries exhibited misconceptions about combustion, as manifested by erroneous explanations for what had happened. However, in an earlier study (Prieto, Watson, & Dillon, 1992; Watson & Prieto, 1994), it was argued that the different methods used in these two countries were significant and affected students' understanding of the topic.

Ayas and Ozmen (2003) studied how students aged fifteen and sixteen comprehended the law of the conservation of mass in a closed system. They found a number of misconceptions among the students, some of whom stated that when a solid is precipitated in a chemical reaction the total mass increases, because the solid is heavier than the liquid, whereas when combustion is incomplete in a closed system, the total mass of reagents and products always decreases. However, Driver et al. (1985) found that almost one-half of the students replied that the mass of an iron coil will decrease after combustion, but only one-third of them replied that a rusty nail has more mass. A study of eighty-seven students (forty-one in high school and forty-six in middle school) in Turkey revealed misconceptions about the conservation of matter, its chemical composition at various stages, and the behavior of molecules during a chemical process at the microscopic level (Leigh & Mehmet, 2012). Another study on combustion reactions indicated that students aged eight to thirteen do not give a correct explanation of combustion, the role of oxygen, and dissociation (Gabel, Makinster, Monaghan, & Stockton, 2007).

Dayan (2005) focused on conceptions of the conservation of mass during combustion among students in the Jewish sector. She found that twice as many students gave correct answers regarding the conservation of mass during combustion in both open and closed systems after the subject had been taught than before.

The law of the conservation of mass is not easy for students to understand; it requires an understanding of chemical reactions (Ayas & Ozmen, 2003). It is a fundamental topic in the chemistry syllabus. Students often retain misconceptions about it even after the subject has been taught. For example, in the case of the combustion of a gas, students find it hard to comprehend that when it takes place in an open system, mass is added. Students' answers are intuitive (Melamed, 2000) and/or naïve (Pundak, Rosner, & Maharshak, 2005), and reflect a misrepresentation of scientific conceptions. One possible reason for this is that students may find it difficult to distinguish the macroscopic from the microscopic world, and therefore, do not understand chemical reactions and the conservation of mass (Sanz, 2006).

Because students in middle school do not gain a proper understanding of the chemical process mentioned in the syllabus, involving conservation or the change in mass during combustion, they find it difficult to answer questions on this subject in the matriculation examination, owing to their not having internalized learning strategies based on scientific thinking.

Children should be introduced at an early stage of education to learning strategies in various domains of knowledge, through research, laboratory experimentation, and text analysis. This is important because such students will, at a more advanced stage, be able to more successfully engage in scientific thinking in their answers (Mendelowitz, 1996).

In Israel, various studies have been carried out in the teaching of sciences that examined cultural-sector differences between Arabs and Jews (Birenbaum, Nasser, & Tatsuoka, 2007; Dkeidek, Mamlok-Naaman, & Hofstein, 2011; Markic et al., 2016; Tamir & Caridin, 1985). Most of the findings in these studies indicated many differences between the two sectors.

Tamir and Caridin, (1993) showed that the achievement of Arab students are lower when the task requires abstract thinking. Arab culture is known for its tendency to promote learning by reciting and memorizing facts rather than Jewish culture. A study by Abdu (1999), which examined the concept of "living creature" among a large Arab population of young students (grades 5, 6 and 10) and adults (including science teachers and non-science teachers) found that 12% of the teachers (including Science teachers) attributed life traits to objects: Cloud and fire, a slightly lower percentage of those objects as living among their students (17%). He found that the cultural component has a clear effect in the classification of inanimate objects as living or still. The reasons given during personal interviews attributed the incorrect classifications of these inanimate to religious-cultural influences, such as the "holy fire" which appears in the church's ceremony. The Quran also states that during a thunderstorm, thunder and lightning show that the clouds are "praying".

Birenbaum et al. (2007) in a study that examined the gender and ethnicity effect on mathematics achievements in an international test, in a representative sample of Arabs and Jews from the 8th grade in Israel, found a large gap in the achievement for the benefit of Jewish students. The researchers attributed that to cultural differences between Arabs and Jews in Israeli society, as well as differences in learning environments.

In addition, a comparative study by Dkeidek et al., (2012) to examine the socio-sectoral background of students on the investigation of the chemistry laboratory in secondary schools in both the Arab and Jewish sectors, there were differences between Arab students and Jewish students (who study chemistry with inquiry approach) regarding their perception of the learning environment: Arab students had a more positive attitude than Jewish students regarding practical work in the laboratory. The ability of questions asking as a result of reading a scientific paper, and/or following a new research experiment, was higher among Jewish in terms of number questions and their cognitive level. The researcher explains that to differences in culture, tradition, norms, social structure and lifestyle.

Objectives and Research Questions

The main goal of this study was to reveal the misconceptions among middle-school students in the Arab sector in Israel regarding the subject of the conservation of mass during combustion in closed systems, and the changes in mass in open systems, before and after the subject is taught. Another goal was to compare the findings in the Arab sector to those in the Jewish sector concerning the role of oxygen atoms in combustion, understanding the law of the conservation of mass, and changes in mass in various situations.

For that purpose, we formulated the following two research questions:

1. What are the conceptions of eighth grade students in the Arab sector regarding the conservation of mass during combustion in a closed *versus* an open system before the subject is taught, and how do these conceptions change after it is taught?
2. How do the conceptions of eighth grade students in the Arab sector differ from those of their peers in the Jewish sector regarding the conservation of mass during combustion in a closed *versus* an open system before the subject is taught, and how do they change after it is taught?

METHODS AND RESEARCH SAMPLE

Israel is a multicultural state with the Jewish and the Arab communities as being the biggest sectors. The schooling system is the same for the Jewish and Arab sectors. Schooling is compulsory until the age of 16. In upper secondary education different types of schools with different academic and vocational orientations are available. However, Israel has a centralized educational system. The syllabi and curricula are regulated by the Ministry of Education. Only the language of teaching and cultural issues in the curriculum are specific for the respective sector. From the 1990s on words, the Ministry of Education is in charge for the long-term and dynamic development of science curricula and its implementation.

The sample consisted of students in six heterogeneous eighth grade classes (N=195) from a two secondary middle school in the Arab sector with similar socio-economic backgrounds. The students were selected using a convenience sample. The general criteria by which the students were chosen were as follows: a willingness to cooperate throughout the entire study, concentration and perseverance, passable verbal expression skills, and varied learning ability in class via experiments and discussions. The study conducted in the Jewish sector took place in a six-year comprehensive school. The study population consisted of three heterogeneous eighth grade classes (N=105), with students of varying cognitive abilities and from similar socio-economic backgrounds. In seventh grade the students from both groups had learned about the characteristics of matter, and its molecular structure, as well as about chemical and physical processes, including the conservation of mass and energy.

In this study, a quasi-experimental research method, was used**.** A questionnaire, consisting of ten open and closed questions focusing on the conservation of mass during combustion, was administered to the students. The questions were taken from three different sources: Questions 1-4 and 6-9 from Dayan (2005), question 5 from Ayas and Ozmen (2003), and question 10 from the Israel Ministry of Education's approved syllabus for middle school (Levy Nahum, Moyal, Somekh, & Koshinsky, 2010). The questions required students to provide the correct answer and some also requested an explanation. The questionnaire consisted of two parts: The first part (questions 1-5) consisted of questions about the conservation of mass during combustion in a closed system, whereas the second part (questions 6-10) consisted of questions about the conservation of mass during combustion in an open system. The questionnaire was adapted mainly from that of Dayan (2005) and was modified for the present study using a pilot study consisting of 32 eighth grade pupils.

Two types of validation processes were conducted: The questionnaire underwent of several types: *Content validity*. The content validation was conducted by four experts from science education: one doctor of chemistry and two doctors of science education and a veteran teacher of chemistry in junior high schools. This group received the questionnaire for review and its members expressed their opinion on the scope, content and form of the questionnaire. The comments they made were taken into consideration and the questionnaire was amended accordingly. *Criterion validity*. The questions in the questionnaire were written in accordance with the formal curriculum designed by the Ministry of Education for the relevant 8th grade. The achievement test was content validated by and checked by a group of 5 experience Arab teachers who teach the topics of the test. The α-Cronbach reliability coefficient (for the Hebrew version) of the test questionnaire was 0.83 Dayan (2005).

Misconceptions were tested by means of the ten questions in the questionnaire. For each question the number of correct and incorrect judgments was checked, before and after the subject had been taught. The responses were divided according to the explanations given by the students and the percentage of correct and incorrect explanations, before and after the subject had been taught, was calculated. The distribution of correct answers and explanations was calculated according to the percentage of correct answers in the questionnaire's two parts (closed and open systems), before and after the subject had been taught. Finally, the data elicited from the questions about conservation of mass during combustion in a closed (questions 1-4) and in an open system (questions 6-9) for the Arab sector were compared with those for the Jewish sector (Dayan, 2005). A t-test was made for dependent samples where a comparison was needed.

Research Procedure

The questionnaire was distributed twice in science class: before the subject was taught and again after the subject had been taught over the course of six lessons, including experiments and class discussions, as follows:

Lesson 1: The idea of macroscopic and microscopic levels in chemistry.

Lesson 2: The difference between physical and chemical change.

Lesson 3: Combustion as a chemical process, and the law of the conservation of mass.

Lessons 4-6: Measurement of materials in different states, before and after combustion, in an open and a closed system, using experiments and classroom discussions.

During the entire teaching process, every lesson ended with a summary based on a classroom discussion concerning students' preexisting conceptions and the conceptions they had acquired during the lesson. In the last stage the questionnaire was distributed again to see whether students' conceptions had changed following the lessons. Students were given forty-five minutes to fill it in.

RESULTS

Findings for the First Research Question

First, we will present the main misconceptions from both the open and closed systems.

Table 1. Eighth grade students' misconceptions about the conservation of mass during combustion in a closed and an open system

Closed system	Open system
• Combustion causes a decrease in mass, because some of the material evaporates.	• When a solid piece of matter (a strip of magnesium) burns, the resulting mass will be less than the original solid, because it disintegrated and became lighter.
• The system's mass will increase because oxygen atoms from the air combine with the matter during combustion.	• When a magnesium strip burns, the resulting mass will be less than that of the solid; light gasses are formed.
• The mass will decrease because some of the oxygen atoms in the air disappeared during combustion.	• When a solid (iron) burns, the resulting mass will be smaller, because the volume decreased.
• The mass is not equal because some of the oxygen atoms in the air disappeared.	• After a candle is lit, the system's mass grows because oxygen atoms have been added.
• In a closed system there is no oxygen; therefore, combustion will not take place and the mass will not change.	• After a candle is lit, the system's mass grows because the light's mass is added.
• The ash produced in combustion is heavier than the material that was burned; therefore, the mass increases.	• When a piece of paper is burned the mass of the product is less because the ash that is formed consists of small pieces that fall apart.
• The conservation of mass depends on the state of the product of combustion.	

As shown in **Table 2**, answers to questions 1-10, regarding eighth grade students' conceptions of the conservation of mass during combustion in a closed and open system.

Table 2. Summary of students' responses in Arab sector to questions 1-5, on the conservation of mass during combustion in closed and open systems, before and after the subject is taught (N-195)

Question no.	1		2		3		4		5	
Judgment	Before subject taught	After subject taught	Before subject taught	After subject taught	Before subject taught	After subject taught	Before subject taught	After subject taught	Before subject taught	After subject taught
Closed system										
Correct	46%	79%	36%	81%	57%	79%	39%	69%	A. 75%	89%
									B. 76%	87%
Incorrect	54%	21%	64%	19%	43%	21%	61%	31%	A. 25%	11%
									B. 24%	13%
Open system										
Question no.	**6**		**7**		**8**		**9**		**10**	
Correct	66%	81%	39%	54%	82%	90%	20%	56%	A. 70%	86%
Incorrect	34%	19%	61%	46%	18%	10%	80%	44%	A. 30%	14%

Table 3. Means and standard deviations of student conceptions in Arab sector of the conservation of mass during combustion in closed and open systems before and after the subject was taught, and the values of the t-test (N-195)

Conceptions (correct/incorrect)	Before/After	Mean	SD	t-value
Closed system				
Correct	Before	54.84	16.60	t=-5.109**
	After	80.66	6.76	
Incorrect	Before	45.16	14.73	t=6.281**
	After	19.34	7.56	
Open system				
Correct	Before	55.40	16.44	t=-3.901*
	After	73.40	9.57	
Incorrect	Before	44.60	14.73	t=4.102*
	After	26.60	7.56	

*p < .05, **p <.01

As shown in **Table 2**, the percentage of misconceptions held by eighth grade students concerning the conservation of mass during combustion in a closed system was larger before the subject was taught than afterwards. The percentage of misconceptions held by eighth grade students concerning the conservation of mass during combustion in an open system was larger before the subject was taught than afterwards.

In order to determine the statistical significance of the effect of teaching on the number of misconceptions among students, a t-test was conducted on dependent samples. The findings are presented in **Table 3**.

As **Table 3** shows, there is a significant difference between the means: The mean for misconceptions regarding the conservation of mass during combustion in a closed system before the subject was taught (M=45.16, SD=14.73) was significantly higher than after the subject was taught (M=19.34, SD=7.56). The findings point to a significant difference between means: The mean for misconceptions regarding the conservation of mass during combustion in an open system before the subject was taught (M=44.60, SD=14.73) was significantly higher than after the subject was taught (M=26.60, SD=7.56). There was a significant difference after the subject had been taught between means in a closed system (M=80.66, SD=6.76), in contrast with an open system (M=73.40, SD=16.44). Before the subject had been taught, the means were very similar.

Findings for the Second Research Question

After the questionnaires were returned, the results (answers) for questions 1-4 (closed system) and 6-9 (open system) were compared with the results to the respective questions in the questionnaire used by Dayan (2005). The students' responses to each question were classified as either correct or incorrect.

As **Table 4** shows, the two sectors differed with respect to the percentage of students' correct answers regarding the subject of the conservation of mass during combustion in a closed system in questions 3 and 4, whereas the difference in questions 1 and 2 was less significant. Furthermore, the percentages of correct answers after the subject had been taught were different in the two sectors: 81 percent of students in the Arab sector provided a correct judgment for question 2, in contrast with only 68 percent of the students in the Jewish sector. In the other questions, the differences between the sectors were not significant. **Table 4** also shows that the two sectors differed with respect to the percentage of correct answers by students regarding the conservation of mass during combustion in an open system before the subject was taught, in all questions except for question 9, where no significant difference

Table 4. Distribution of correct answers by students of the Arab versus the Jewish sector, for combustion in a closed system (questions 1-4) and an open system (questions 6-9) before and after the subject was taught

Question no.	Arab sector *(N-195)*		Jewish sector *(N-105)*	
	Before	**After**	**Before**	**After**
		Closed system		
1	46%	79%	42%	72%
2	36%	81%	28%	68%
3	57%	79%	24%	73%
4	39%	69%	22%	39%
		Open system		
6	66%	81%	38%	82%
7	39%	54%	53%	73%
8	82%	90%	37%	78%
9	20%	56%	18%	74%

Table 5. Means and standard deviations for Arab and Jewish sector eighth grade students' conceptions regarding the conservation of mass during combustion in an open and a closed system, before and after the subject was taught, and the t-test values

Conceptions – closed system		Arab sector *(N-195)*		Jewish sector *(N-105)*		t-value
		Mean	**SD**	**Mean**	**SD**	
Correct	Before subject was taught	44.50	16.60	29	9.50	t=2.347*
	After subject was taught	77	6.76	70.5	2.94	t=0.778
Incorrect	Before subject was taught	56.50	14.73	71	9.50	t=-3.599**
	After subject was taught	23	6.14	29.5	2.94	t=-3.523**
Conceptions – open system						
Correct	Before subject was taught	51.75	14.0	36.50	15.15	t=1.016
	After subject was taught	70.25	6.57	76.75	4.11	t=-1.424
Incorrect	Before subject was taught	48.25	16.30	63.50	15.15	t=-1.737
	After subject was taught	29.75	4.57	23.25	4.11	t=0.124

*$p < .05$, **$p < .01$

was observed. For question 6, 66 percent of students in the Arab sector gave a correct answer, compared with 38 percent in the Jewish sector, whereas for question 7, 39 percent of the students in the Arab sector gave a correct answer, compared with 53 percent in the Jewish sector. The largest difference was in question 8, where 82 percent of the students in the Arab sector gave a correct answer, compared with only 37 percent of the students in the Jewish sector. After the subject was taught, the percentage of correct answers differed in the two sectors for all questions except question 6. Seventy-three percent of the students in the Jewish sector gave a correct answer for question 7, compared with 54 percent of students in the Arab sector. For question 8, 90 percent of the students in the Arab sector gave a correct answer, compared with 78 percent in the Jewish sector. Again, for question 9, in the Jewish sector 74 percent of the students gave a correct answer, compared with 56 percent in the Arab sector.

In order to determine whether the differences between students' conceptions in the two sectors were statistically significant, we conducted a t-test on the independent samples. The findings are presented in **Table 5**.

As **Table 5** shows, a significant difference exists between the percentages of correct answers given by Arab and Jewish eighth grade students with respect to the conservation of mass during combustion in a closed system, before the subject was taught (t=2.347, $p < .05$). No significant difference between the two sectors was found after the subject had been taught.

With respect to the conservation of mass during combustion in an open system, the differences between students of the two sectors were not significant, both before and after the subject was taught.

DISCUSSION

The findings indicate that eighth grade students adhere to a number of misconceptions concerning the conservation of mass in both open and closed systems, before and after the subject is taught. As expected, the percentage of misconceptions before the subject was taught was greater than after it was taught.

Students' explanations were occasionally based on visual considerations, which subsequently changed to logical arguments based on the scientific explanation of combustion as oxidation, accompanied by the emission of heat and light (Melamed, 2000). This was concluded, based on experiments performed by the students in the classroom, in which they measured masses before and after combustion in an open and a closed system. Visual considerations were evident in the answers to question 1, such as "the volume will be smaller, and so will the mass" and to question 2, such as "the mass is not equal because during combustion the mass decreases". A much smaller percentage of students had an erroneous explanation after the subject had been taught than before. A possible explanation for retention of the erroneous explanation is that it involved acquired concepts that were not easy to replace (Nussbaum & Yehieli, 1995), or that the error is intuitive rather than due to lack of knowledge, that is, it reflects a student's opinion that was formed without reliance on either previous or new knowledge (Melamed, 2000). Students also had explanations based on a visual consideration for question 7, "the mass is smaller than before the candle was lit, because it shrinks and becomes smaller", and for question 9, "because the paper was solid and then became ash"; these are erroneous judgments based on general misconceptions (Nussbaum & Yehieli, 1995, p. 15), which are quite tenacious: students hold on to such misconceptions because they believe that they are reasonable, since they are based on their own experiences, and therefore, they find it difficult to replace them (Yaakov, 1988).

Among the answers to question 1 concerning a closed system, students noted that part of the matter evaporated and explained that when this happened, the matter disappeared. This is also consistent with the findings of Ochsendorf and Pyke (2004), and Barker and Miller (1999), where 37 percent of the students replied that there was a change in mass.

In their answers to question 3, more students explained that "the matter turned into gas" before the subject was taught than afterwards. Similar responses were noted by Furio-Mas, Perez, and Harris (1987), who found that students believed that "when gas is released the mass becomes smaller". In answering question 7, concerning an open system, students argued that the mass "decreased, because the wax became liquefied". Before the subject was taught, some of the students said that the mass was "equal, because the matter only changed its state".

Many researchers who studied this topic concluded that students continue to adhere to misconceptions even after the subject was taught (Ayas & Ozmen, 2003; Gabel, Makinster, Monaghan, & Stockton, 2007; Haider, 1996; Ochsendorf & Pyke, 2004). Similarly, to previous studies (Driver, 1985), an analysis of the findings revealed that some students use non-existent concepts in order to explain their replies to questions regarding chemical reactions.

Comparison of open and closed systems: A comparative analysis of students' answers to questions 1-5 on closed systems and questions 6-10 on open systems showed that eighth grade students did not distinguish between mass conservation in the case of chemical reactions through combustion in the two system types.

In their answers to questions 1 and 3, regarding combustion in a closed system, a large percentage of students used erroneous judgments before (and some even after) the subject had been taught, and gave the incorrect answer that "oxygen atoms were added from the air, and therefore, the mass increased", an argument that ignores the fact that the system is closed. They did not realize that the oxygen used for combustion was already part of the system and that it did not enter from the outside.

In answering question 3, students said that "the mass decreases because during combustion there were oxygen atoms, which subsequently disappeared". This conception is in line with similar results obtained by Ayas and Ozmen (2003), who found that students adhere to the misconception that mass always decreases in chemical reactions in a closed system.

In answering question 7 regarding a candle burning in an open system, students erroneously replied that the "candle's mass after it burned was equal to its mass before", and explained that this occurred because "no matter was added and none was taken away". Similarly, Ochsendorf and Pyke (2004) found that students hold on to misconceptions about chemical reactions ("if the product's matter is only transformed"). They realize that a chemical reaction has taken place but do not distinguish between an open and a closed system.

In their answers to question 9, before the subject was taught, some students said that "no oxygen atoms were added". Even after it was taught, some students continued to adhere to misconceptions owing to their not having made a distinction between open and closed systems, in addition to confusion about the nature of the chemical reactions that take place during combustion. The answers to question 10 confirm this: some of the students said "that gases are produced that are released into the air" during the burning of a strip of magnesium.

In their answers the students used physical changes that take place during combustion. When learning the subject, apparently they are not taught the difference between physical and chemical changes in combustion, arguing that the burned matter merely changed form. The students continued to adhere to this misconception even after the subject had been taught, in line with the findings of Ayas and Ozmen (2003), based on chemical changes during combustion in a closed and an open system.

Among the students who took part in the study, certain serious misconceptions were found concerning vital concepts in chemistry that should have been corrected before high school. In a study of high-school students who had just finished a lesson on chemical changes, the students were exposed to the topic of chemical reactions during oxygen reduction and were asked to explain what had happened. The study showed that the students could not distinguish between physical and chemical changes and were unable to explain specific processes (such as the release of gas). Some, in their replies, referred to everyday experiences. The study's results show the need for fundamental changes in how chemistry is taught in school (Hesse, 2006).

To conclude, the percentage of wrong answers seems to show that students had more difficulty with questions about open than about closed systems after the subject had been taught (see **Table 6**), whereas the differences in students' answers to questions concerning the two kinds of systems before the subject had been taught were not very large.

The Arab versus the Jewish sector: First of all, it should be pointed out that in the Arab sector the topic at hand (conservation and the change in mass during combustion) was taught for six lessons, whereas it was taught for nine lessons in the Jewish sector, due to more discussions and experiments in the latter. However, the curriculum is identical for all middle schools in the country and is certified by the Israel Ministry of Education (Levy Nahum et al., 2010).

Questions 1-4 deal with the conservation of mass for different states of matter in a closed system. The distribution of students' answers for questions 1 and 2 were nearly identical in the two sectors, before and after the subject had been taught. It is important to note that the first two questions do not require very sophisticated thinking, since they deal with the combustion of solids, something with which students are generally familiar from their everyday lives. Therefore, the distributions of answers for students in both sectors were almost identical. The same is true of the distribution of answers to questions 3 and 4, which also deal with materials with which the students are familiar. Question 3 deals with the combustion of a liquid, which was already taught in class in the present study, and also in the Jewish sector; the distribution of answers highlights this. In question 4 the subject is again "solids", but this time students know the result, having learned about the law of the conservation of matter in a closed system. However, the distribution of the answers to questions 3 and 4 before the subject had been taught was different in the two sectors, because the students came from different backgrounds, different schools, and perhaps also experienced different teaching methods in primary school. For this reason, students possess different conceptions concerning the law of the conservation of mass (Boujaoude, 1991).

A perusal of the findings with respect to questions 6-9 regarding the law of the conservation of mass in a solid in an open system shows the distribution of answers for the two sectors.

As for question 6, the distribution of answers after the subject had been taught was nearly identical in both sectors. In the experiment described, in these questions the students referred to the addition of oxygen atoms, as reflected by the comment "a white substance was created in the air", clearly indicating that the students treated the system as closed. However, from the answers to question 7, we see that in the Arab sector a larger percentage of students maintained their misconceptions after the subject had been taught than was the case in the Jewish sector. Question 7 is not easy, since it requires thinking about the chemical process that takes place when a candle burns and the production of new materials, some of which are in a gaseous state and are released into the air. The arguments provided by the students for this question were based on visual considerations, that is, on the physical changes, rather than on the gases released into the air, and therefore, these students did not take the mass of these gases into consideration. Question 7 is similar to the question posed by Ochsendor and Pyke (2004), who asked about the mass of a piece of wood that burned completely and turned into ash in an open system; some of the students maintained that the mass decreased.

The distribution of students' correct answers to question 8 in the Arab sector before and after the subject was taught shows that even before the subject was taught, many students gave correct answers and this situation improved even more after it was taught. The question dealt with the combustion of iron oxide in air; the words "oxide" and "air" both appeared in the question, thus helping students realize that oxygen atoms were added and therefore, the mass increased. This was relatively easy for the students because they had already encountered this issue when they were taught about the combustion of a piece of zinc. In the Jewish sector, on the other hand, the percentage of correct answers before the subject was taught was quite low, but improved considerably after it had been taught.

In their answers to question 9 many of the students in the Arab sector, but considerably fewer in the Jewish sector, retained misconceptions after the subject had been taught. Question 9 is quite similar to question 7, but in question 9 the correct answer is already included in the question itself, and students were only required to explain it. The distribution of students' answers in both sectors after the subject had been taught was similar for both questions. The analysis of question 9 is identical to that of question 7, namely, that it requires students to think carefully about why the mass of the paper decreased after combustion. To do this, it is necessary to consider the chemical process that took place in an open system, as well as the fact that new materials are formed, some of which are gases that are released into the air. These results are in line with previous studies which deals with different sectors and cultures and their impact on coping in the classroom and in the school received much attention. A comparison between the Jewish and the Arab populations in Israel is interesting because it contains many factors that can be addressed, including cultural-ethnic factors, the influence of religion, intellectual ability, academic achievements, and more. In Israel, various studies have been carried out in the teaching of sciences that examined cultural-sector differences between Arabs and Jews (Birenbaum et al., 2007; Dkeidek et al., 2012; Markic et al., 2016; Tamir & Caridin, 1985). Most of the findings in these studies indicated many differences between the two sectors.

Thus, with respect to the second research question, the study's findings show that conceptual differences exist between eighth graders in the two sectors. The differences were particularly significant in the answers to questions 7 and 9. These questions dealt with open systems, which required a higher level of thinking; in their answers the students in the Arab sector had more misconceptions than their peers in the Jewish sector had. On the other hand, in questions 1-3, which dealt with closed systems, students in the Arab sectors had fewer misconceptions than did the students in the Jewish sector. In question 4 the results for both sectors were identical.

CONCLUSIONS AND RECOMMENDATIONS

It is important to note that students' erroneous answers were mostly based on visual considerations due to changes in the states of matter, and due to students' inability to distinguish between chemical reactions during combustion that took place in closed *versus* open systems, and in general, the effect on the mass of a system's being closed or open. Overall, the percentage of misconceptions before the subject had been taught was greater than after it had been taught in both sectors and for all questions, an unsurprising result. The present study revealed some misconceptions that proved difficult to change, due to interaction with the environment (Yaakov, 1988). Another unambiguous conclusion is that the percentage of misconceptions about the conservation of mass in an open system is higher than in a closed system among students of both sectors. However, the misconceptions in the two sectors are not always the same, especially with respect to questions that require high-level thinking, conceptions having to do with closed systems, as well as combustion in an open system with the addition of oxygen atoms.

The limitations of this study include the fact that the students studied are from a specific area in the Arab sector in Israel. Another limitation is that the results obtained in the present study are only in the Arab sector and were compared to results of a previous study conducted in the Jewish sector (Dayan, 2005) not at the same time of this study. In light of the study's results, it is recommended that eighth grade students' misconceptions regarding combustion be revealed before the subject is taught. Explanations should be accompanied by experiments that show the effect of oxygen on matter, and the subject should be addressed not only from a visual perspective—it should also include a discussion of the relevant chemical reaction. This will provide students with the correct meaning of the concept. It is important to discuss the possible source of the misconceptions, to determine whether these misconceptions may lead to others in other domains, and to discover ways for solving and preventing this problem (Hirsch & Amir, 2001).

This study has some limitations. The first one is that the sample of the study is not statistical; it depended on accessible classes in the Arab and the Jewish sectors by the teachers' agreement and the principal's permision to take part in the study. Besides, the study conclusions are suitable to the population that was examined, and it is necessary to be careful to generalize them to the whole Arab and Jewish sectors. Probably, if another study is conducted in different geographical areas and includes other communities, it will add different conclusions.

Finally, to clarify the complex picture of misconceptions among students, further research is needed. It is possible that conducting in-depth interviews will help to create a deeper understanding of various factors, sector and culture dependent that shapes the entire range of variables that influence the creation of misconceptions.

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APPENDIX 1

Knowledge Questionnaire

Dear student

Please answer the following questions;

1. Choose the right sentence to the best of your understanding
2. Explain as needed.

Questions:

1. A piece of phosphorus with a little water were kept in a closed bottle. The mass of the bottle and its contents was 400 grams. Sunrays passing through the lens focused on the phosphorus and caused it to burn**.** The slowly formed white smoke dissolved in the water found in the bottle. The mass of the bottle after burning the piece of phosphorus:

A. Equals 400 grams.

B. more than 400 grams.

C. less than 400 grams.

Explain:

……

……

……

2. An astronaut was smoking a cigarette in a perfectly sealed spacecraft. Therefore, the mass of the space ship (with everything in it) after smoking will be:

A. Bigger

B. smaller

C. Equal to the mass before smoking.

Explain………
…………………………………………………..

3. Measure liquid alcohol mass in a closed container. Then, burn the alcohol in the closed container and measure its mass again**.**

Does the mass of the closed vessel after the burning of alcohol remain equal or does it change? Please explain your answer:

……

……

4. Measure the mass of a piece of paper while the vessel is closed. Then, burn the piece of paper in the closed tool and measure its mass again. The mass of the sealed tool with the sheet of paper is:

A. Bigger than the mass of the vessel with the page before its burning.

B. Smaller than the mass of the vessel with the sheet before its burning.

C. Equal to the mass of the vessel with the page before its burning.

5. Measure 5 grams of steel were measured; then burned and the mass was measured again. It was six-gram.

A. What led to the rise of mass?

……

……

B. What happens in your opinion if the experiment is done with a closed tool?

……

……

6. As a result of burning magnesium in the air, white matter is obtained.

What can we say about the mass of white matter?

A. Less than the mass of magnesium, because magnesium became lighter when heated.

B. Less than the mass of magnesium, because the magnesium disintegrated.

C. Equal to the mass of magnesium, because oxygen atoms from the air were added to the atoms of magnesium.

7. Place a candle in the air on the scales and read its mass. Then, light the candle, and read its mass again. The mass of the candle, after it was burned, will be:

A. Smaller than before it was burned.

B. Bigger than before it was burned.

C. Equal to the mass before it was burned.

Explain:

……

……

……

8. When iron wool is burned in the air, we get gray iron oxide. What can we say about the mass of gray matter compared to the mass of iron wool?

A. Bigger, because the material has spread.

B. Bigger, because the material was merged with oxygen from the air.

C. Smaller, because the volume is small.

D. Smaller, because the iron disintegrated.

9. The mass of a sheet of paper was measured and burned in the air. Then, the ash mass of the burned paper was measured. It turned out that it had become smaller.

Explain why the ash mass of the burned page became smaller after burning the paper in the open air?

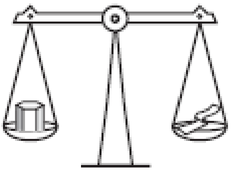
Explain:

……

……

……

10. The figure in front of you; illustrates the balance of the scales, with one stripe of magnesium on top of it before burning it**.**



A. Choose the figure that illustrates the stripe of magnesium after burning (Arrow refers to magnesium oxide).

1

2

B. What led to the change in magnesium mass after its combustion?

………

………

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The Secondary-Student Science Learning Motivation in Korea and Indonesia

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ABSTRACT

The previous studies on motivation have merely revealed the effects of gender, educational level, and country; however, the effect of the interactions between these variables on motivation has not yet been uncovered. The present study aims to statistically examine whether or not the interactions between these three variables can significantly impact the student science learning motivation. A set of the Science Motivation Questionnaire-II (SMQ-II) was administered to 867 Korean and 954 Indonesian secondary students (middle and high schools), and the Rasch analysis was performed to identify the validity and reliability of the instrument. To reveal the aim of this study, a three-way ANOVA and Pearson-correlation tests were used. Based on the findings, the interactions between country, gender, and educational level exerted significant effects on the student science learning motivation, as well as the remaining motivational components. The findings are discussed with respect to the factorial complexity that contributes to the student science learning motivation and the differences between the learning-motivation levels of the students of the two countries.

Keywords: cross-cultural, Indonesia, Korea, science motivation, secondary student

INTRODUCTION

The study of the student's cognitive structure has been one of the longstanding topics in the body of science education research. Indeed, the student's cognitive construct is directly associated with the scientific contents that are provided for the student's school learning, and most people think that the outcome of science learning is the development of a cleverness and an understanding of all of the science contents. Therefore, the investigative studies regarding the student cognitive construct have been exaggerated, while a collection of accurate findings has been accumulated. But, due to the investigational focus on the student's cognitive construct, other constructs besides the cognitive construct continue to be marginalized and are explored to a lesser extent (e.g. the affective constructs including the motivation and the interest regarding science learning) (Koballa & Glynn, 2007).

In general, *motivation* refers to the goal-directed activity process that exists in every individual mind (Schunk, Pintrich, & Meece, 2008). Specifically, the motivation to learn science that has been stated by Lee and Brophy (1996) is the student's desire to achieve a goal for an improved understanding of science including his or her involvement in science-related tasks and activities. Science education researchers (e.g., Koballa & Glynn, 2007; Vedder-Weiss & Fortus, 2013) have argued that an investigation of the student science learning motivation needs to recognize the motivation as a crucial stimulus of the student's cognitive structure. In addition, the student science learning motivation is also known as an important aspect of the prediction of a student's later science career and education (Maltese & Tai, 2010).

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Contribution of this paper to the literature

- An extensive review of the science education system of Indonesia and Korea is provided.
- A statistical demonstration of the interaction effects between country, gender, and educational level in terms of the student's science learning motivation.
- Support regarding the idea that the student learning motivation is a complex psychological aspect that is not dependent on only one factor.

The reason that the motivation impacts on the student learning outcome is the fundamental nature of the motivational aspect of the student learning approach that is defined as the way that a student processes academic tasks (Chin & Brown, 2000); that is, the entire student's learning process is driven by the student motivation. Yet, the actual motivational magnitude of the student in the learning of science varies, and Osborne, Simon, and Collins (2003) and Tang and Neber (2008) argue that the student motivation is impacted by several socially related factors, with country, gender, educational level, and age being of particular importance. Alexander, Johnson, and Kelly (2012), for instance, found that in the early childhood and primary-school years of American girls, the subjects seemed to show a lesser interest and motivation regarding the learning of science-related topics compared with their male peers. Similar to Alexander et al. (2012), in a sample of British primary-school students, Jarvis and Pell (2005) found a lower pre-intervention motivation among the girls regarding the learning of science compared with the boys. In a sample of Turkish primary-level students, however, Cavas (2011) did not find any gender differences in the learning of science. Moreover, at the higher levels of education and the student age, the 2015 findings of one of the notable triennial international assessments, the Program for International Student Assessment (PISA), regarding 15-year-old students showed that the gender differences regarding the motivation to learn science varied between countries (Organization for Economic Cooperation and Development [OECD], 2016).

Moreover, regarding the educational year and the student age, the study of Vedder-Weiss and Fortus (2011) found a declining trend of the science learning motivation for Israeli students from the fifth grade to the eighth grade. Similar declining trends were also obtained by Galton (2009), who studied British sixth and seventh graders. However, a study on Filipino students conducted by Libao et al. (2016), where the educational year was also considered, found that the higher levels of academic performance positively correlate with the student science learning motivation. The evidences from these studies indicate the uniqueness of different countries, each with a different culture and socioeconomic status, with respect to the gender and age influences on the science learning motivation.

Regarding the complexity of the science learning motivation, which is not dependent on only one social factor, the student science learning motivation may be affected by the interactions between gender, educational year, and country. To date, researchers have not examined these three dependent variables together in terms of the student science learning motivation; thus, the current study attempts to confirm the complexity of the science learning motivation through a consideration and examination of the influence of those three significant factors on the science learning motivation based on statistical findings. Prior to the presentation of the findings and discussion of this study, a literature review regarding the science learning motivation and descriptions of the scientific- and general-education types of Indonesia and Korea are provided.

LITERATURE REVIEW

The Science Learning Motivation and the Roles of Educational Level and Gender in its Shaping

According to the social cognitive theory (SCT) proposed by Bandura (1986), human behavior is influenced by the reciprocal interactions between individual factors such as perception, belief, emotion, culture, and society. In addition to the SCT, it is assumed that individuals are active beings who can individually adjust their behaviors and perceptions to achieve their desired goals. In view of the SCT, motivation is elucidated as a goal-directed process that involves energized, directed, and sustained activities (Schunk & Usher, 2012), and it is influenced by a fair number of factors such as various cognitive, emotional, and surrounding-environment factors. In terms of the high motivation that can be achieved by students, Murayama et al. (2013) and Lee et al. (2016) stated that it is closely related to a student's participation in the so-called "active learning activities" as part of his or her effort to gain a desirable academic achievement; therefore, many educators have attempted to understand the learning-motivation characteristics. In particular, the focus of many of the prior studies that are related to the learning motivation comprises factors such as the individual perception of self (e.g., *self-efficacy*), the task value, and the student intended goal (Pintrich, 2003; Wigfield, Cambria, & Eccles, 2012).

In the field of science education research, only a few investigative studies regarding a comparison of the student affective domains with the student cognitive factors such as concept, theory, and inquiry have been completed (Fortus, 2014). Among the studies on the affective domains, the attitude toward science was included in the most scrutinized study, while the research on the student science learning motivation is very limited (Fortus, 2014). However, the science learning motivation has been emphasized as a core study element due to its essence that is in accordance with the student participation in science learning activities, as well as the student intention regarding the attainment of a higher academic achievement (Fortus, 2014; Lee et al., 2016; Palmer, 2005). Additionally, experts have found that several social factors play roles in the shaping of the student learning motivation, including that regarding science learning (e.g., Osborne et al., 2003; Tang & Neber, 2008), and they found that the student learning motivation is shaped by country (including culture and economic status), gender, and educational level. The focus of this section is the elucidation of the influences of the educational level and the gender in terms of the student learning motivation, while that regarding the country effect is described later in the literature-review section of the present paper.

Several educational motivation experts have explained the influence of the student educational level, as well as the student age, the school curriculum, and the difficulty of the learning contents, in the shaping of the student motivation regarding the learning of particular school subjects (e.g., Gottfried, Fleming, & Gottfried, 2001; Lepper, Corpus, & Inyenger, 2005; Meece, Anderman, & Anderman, 2006; Pintrich, 2003; Urdan & Schoenfelder, 2006). Based on the longitudinal studies on motivation that were conducted by Gottfried et al. (2001) and Lepper et al. (2005), the student learning motivation decreased with the increasing of the student age, showing that the learning motivation of students with higher educational levels (mostly older) is lower. Gottfried et al. (2001) further explained that the decreased learning-motivation trend, especially in science, is caused by the higher anxiety levels of the students at the higher educational levels. The competitiveness regarding grades, activities, and the college-admission process at the higher educational levels increases the students' anxiety levels, thereby reducing their learning-effort levels. Moreover, Pintrich (2003) and Urdan and Schoenfelder (2006) have claimed that the school and classroom environments and facilities contribute to the student learning motivation; that is, it is known that schools and classrooms that comprise more facilities and provide more effective teaching methods positively influence the student learning process.

Regarding the manner in which gender shapes the student learning motivation, especially in science, it has been frequently argued that the sporadic stereotyping of science subjects as more masculine is the cause of the gender gap in terms of the science learning motivation (e.g., DeBacker & Nelson, 2000; Meece, Glienke, & Burg, 2006). A study that was conducted by DeBacker and Nelson (2000) found that both male and female students expressed the stereotypical notion regarding the masculine nature of science subjects. Meece et al. (2006) reviewed the sources of the gender stereotyping in terms of the learning motivation and found the following three sources that correlate with each other: parental influence, schooling, and the sociocultural factor. Regarding the parental influence, the stereotypical cultural gender perspectives that favor males more in terms of the excelling of students in the science field compared with females have heavily influenced the way that parents treat their children on the basis of gender. When parents implement this kind of stereotyping, their children's study-field focus tends to be based on their surrounding beliefs; in turn, the parents tend to support this focus by providing the corresponding materials and through the controlling of their schedules accordingly (Larson, Dworkin, & Gillman, 2001; McHale et al., 2004). Consequently, both genders show higher motivation levels in the fields that are derived from their parents' suggestions.

With respect to the schooling influence, Jussim and Harber (2005) argue that the learning motivation is likely to be influenced by the teacher attitudes and perceptions toward the learning activities and interactions in the classroom. In classrooms, the teachers tend to prefer students who are actively engaged in the classroom interactions, and based on the study that was conducted by Jones and Dindia (2004) boys are more active and reflective during the learning process. Consequently, teachers are inclined to interact more with boys than with girls, leading to a decrease of the girls' learning motivation. Moreover, in regard to the mostly abstract concepts of the science subjects, the stereotypical notion indicates that they are more easily learned by the male students compared with the female students, and this also influences teachers in terms of their more favorable treatment of male students.

Regarding the sociocultural factor, the learning-motivation gender gap varies between different cultures and socioeconomic levels (Graham & Taylor, 2002; Meece & Kurtz-Costes, 2001). But, similar patterns have been found in most cultures, where the males are bestowed a higher position, as well as greater educational opportunities, than the females. Consequently, in most cultures, the learning motivation of the males tends to be higher than that of the females.

A number of experts including Glynn et al. (2011) have expanded the meaning of the SCT-derived definition of motivation in the context of science learning. Glynn et al. (2011) have defined the science learning motivation in the following way: "[the] internal state arouses, directs, and sustains science-learning behavior" that consists of the self-efficacy, self-determination, intrinsic motivation, career motivation, and grade motivation in science. They empirically confirmed that these five motivational components interact with each other and constitute the student science learning motivation. The five factors are subsequently described.

Self-efficacy. In SCT, it is assumed that self-efficacy is a key factor in the self-regulation mechanism of human behavior (Bandura, 1986). Self-efficacy refers to one's belief in his or her ability to perform a specific behavior or to reach a specific goal; therefore, self-efficacy in science implies a belief in the student's ability to engage in science subjects or specific science-related behaviors (Mason et al., 2012). An individual with a high self-efficacy should be well synchronized for the performance of certain behaviors and the achievement of desirable goals (Bandura, 1997). A high self-efficacy is also known as a key factor in the prediction of high achievements (Britner, 2008; Lau & Roeser, 2002; Lee et al., 2016). Conversely, since the influence of a successful mastery experience on the formation of self-efficacy is definitive, the formation and effect of self-efficacy could make it a representative example of the active interactions between the behavior and the personal attributes that are defined in the SCT. A number of studies have suggested that self-efficacy is related to positive aspirations regarding science and science-career decisions (Dalgety & Coll, 2006; Nugent et al., 2015).

Self-determination. Self-determination is a factor that contributes to one's motivation and is associated with one's self-regulation. Self-determination refers to the autonomy and the control that are perceived regarding a particular activity or behavior. Regarding *self-determination theory* (SDT), Ryan and Deci (2000) argue that self-determination is an essential component of a student's intrinsic motivation, which apparently correlates with the extrinsic motivation as well. For instance, according to one of the SDT sub-theory called *organismic integration theory* (OIT), it is assumed that an individual tends to be initially disinterested in being a participant in an activity, but the external environment encourages the individual to perform such uninteresting activities. The external encouraging factor or the factor that is from the internalization of the external regulation, in addition to the key of this internalization, is called *autonomy* (Ryan & Deci, 2000). That is, once a student has perceived his or her own behavior as self-determined, the learning behavior that is gained by the student from the external regulation is gradually internalized, and eventually the student is intrinsically motivated.

Intrinsic motivation. Intrinsic motivation refers to a state in which the intent of an act consists of enjoyment and interest. Enjoyment and interest are known as the representative elements of the intrinsic motivation. In addition, a student who is intrinsically connected with science is more likely to participate in science-related activities, recognize positive images of his or her own self, and aspire to work in a science field (Nugent et al., 2015). This motivation is in contrast to the extrinsic motivation, which refers to the student learning that is for the receipt of rewards or the avoidance of punishments (Ryan & Deci, 2000).

Grade motivation. One of the most influential motivational components for a student in terms of learning is the attainment of a high score. It is known that students with a high grade motivation pursue a higher grade and/or score in their science learning; therefore, the role of the grade is important for students in science learning activities. In particular, the score is a positive motivational component, as it can be useful information in the processes of the identification of individual-achievement levels and the controlling of learning activities (Elliot & Moller, 2003). In terms of this grade-based motivation, however, negative effects such as the decreasing of the student autonomous-learning motivation and the increasing of only the performance-avoidance goal can be influential (Pulfre, Buchs, & Butera, 2011).

Career motivation. Career motivation refers to the science learning motivation, because it can help students as they pursue their desired future jobs. A student will possess a high career motivation when the student thinks that his or her science learning can provide a major contribution in the pursuance of the student's desired career. In this sense, science learning is considered as an extrinsic motivation or an instrumental motivation, because it is seen as a means of job attainment (Glynn et al., 2011; OECD, 2016; Wigfield et al., 2012). Glynn et al. (2009) found that the science learning motivation of non-science major students is related to their perception of the relevance of the science learning to their career. Accordingly, the career motivation is not only evident for those students who want to gain a science career, but it is also relevant for many students who are seeking a science-related career. The findings of the study that was conducted by Shin, Ha, and Lee (2017) suggest that the effect of the career motivation on the science learning motivation and the career choices of most students is positive.

Differences between the General and Science Education of Korea and Indonesia

Korean and Indonesian education in context

Korea is known as part of the Confucian culture along with the other East Asian countries, Japan, Taiwan, and China. Korea has been influenced by the Confucian culture for over 1,500 years, and many aspects and customs of Confucian culture still exist in the present time. In Confucian culture, education is greatly emphasized not only in terms of personal growth, but also in terms of societal stability. For a couple of centuries, the interactions between the Confucian and collectivist cultures have influenced the Korean education system. Due to the collectivist culture, children's education has been seen as a family matter rather than a child matter; consequently, families express much interest and expectation regarding the education of their children and invest greatly in this education. The combination of the influences of Confucian culture and a family centeredness has resulted in a Korean passion for excessive education (Seth, 2002). One of the indicators of this educational passion is Korea's high tertiary-education completion rate. According to recent reports on the OECD countries, the tertiary-education completion rate among the young people of Korea is the highest among the OECD countries (OECD, 2016). The Korean enthusiasm for higher education and the achievement of high educational levels by Korean students have been evaluated as a driving force of the economic development that has rapidly occurred over the 60 years since the Korean War (Jones, 2013).

As we have seen, Korea has a national curriculum with a single track 6-3-3 system. The latest national curriculum is the '2015 revised curriculum' (Ministry of Education, 2015). The Korean '2015 revised curriculum' is divided into common basic education (compulsory) with grade 1-9 and select-centered education from grade 10 to 12. The 2015 revised science curriculum is designed to improve student core competencies such as scientific thinking, scientific inquiry ability, scientific problem solving ability, scientific communication, science related participation and lifelong learning ability. In common basic education, it is noted that a "science" subject is systematically organized with core concepts within 'motion and energy,' 'material,' 'life,' and 'earth and universe.' In the use of a select-centered science curriculum, all students in Grade 10 learn the subjects of 'Integrated Science' and 'Science Inquiry Experiment' to cultivate scientific literacy, and from the 11th grade onward, the students can select advanced courses based on their own career development or individual interest. Advanced courses in a select-centered curriculum include 11 subjects such as Physics 1 & 2, Life Science 1 & 2, Chemistry 1 & 2, Earth Science 1 & 2, History of Science etc.

Indonesia is not only known as one of the most bio-diverse countries in the world, and the fourth most-populated, but it has also been recognized as the most linguistically and culturally diverse country due to the existence of 700 living languages and 300 ethnic groups. In addition, Indonesia is known as a religious country, not as secular or Islamic, even though more than 80% of Indonesia's citizens adhere to the Islam religion (BPS, 2013), as five other religions (Protestantism, Catholicism, Hinduism, Buddhism, and Confucianism) are legally considered regarding Indonesia's citizens. It is necessary, however, for Indonesians to adhere to at least one of these six religions. Indonesia's own Pancasila ideology was designed to cope with and accommodate the various cultures and the diversity of Indonesia. Religiosity, though, is more essential than culture in every community and society of Indonesia (Parker, 2017), and not least in terms of education and the national curriculum. In the newest published Indonesian curriculum, "Curriculum 2013", tolerance and spiritual aspects are two of the four core educational competencies, especially regarding the science education. The other two core competencies are knowledge and skill. The significance here is that every taught subject including science should not only be used to enhance the student knowledge and skill in the particular subjects, but also, enhancements of the student tolerance and spiritual aspects are expected. Besides, the teachers as well as the students are encouraged to utilize the resources (natural and cultural) that exist near their school or their local area in their teaching and learning activities. This kind of effort is a way of coping with the diversity of the Indonesian people, as the students are often asked to go outside of the classroom to learn more about the concepts they are being taught.

Moreover, science curriculum in Indonesia is quite different to what it is in Korea, especially for the high school level. Indonesia and Korea have quite a similar science education system for K-9 students, which notes that the science curricula is delivered in class as an effort to develop children's scientific thinking, scientific inquiry ability and scientific problem solving ability. In Indonesian high schools, science subjects are not divided into lower – upper level knowledge and students do not have the authority in selecting the classes. If in Korea students can choose which science subjects that they prefer to be advanced to by taking both basic and advanced classes; it is different however in Indonesia, as it is considered necessary for students to take all science classes – notably the subjects of biology, chemistry and physics for both the lower and upper levels of the student's learning in the classroom.

Additionally, besides the educational-system differences between Indonesia and Korea, both countries share a number of similarities. Most of all, both countries have adopted a national science curriculum with several similar educational directions. For example, in Indonesia's "Curriculum 2013," the development of the scientific behavior and attitudes as well as the scientific knowledge is more emphasized than before. Especially, scientific skills such as observation, questioning, exploration, association, and communication have been included as educational objectives in terms of the preparation of the competencies that are needed by a citizen of the 21st century.

The emphasis of Korea's newest curriculum, "The 2015 Revised Curriculum," is also inquiry-based activities that are for the enhancement of the student scientific skills such as observation, experimentation, argumentation, and communication, rather than merely an understanding of the student basic-science concepts (Ministry of Education, 2015). Especially, the new Korean curriculum is designed for the student interest and enjoyment in science learning that is to a greater extent compared with the previous curricula, as the Ministry of Education seeks to solve the problem of the much lower affective-factor level of Korean students compared with the international average (OECD, 2016). For this purpose, the science learning emphasis comprises situations that are relevant to everyday experiences. This direction of the Korean revised national curriculum of 2015 is similar to the Indonesian national curriculum that encourages science teaching and learning within local contexts.

Moreover, another prevalent similarity comes from the types of cultural value that are upheld by the citizens of both countries, both of which are collectivist societies (Leigh & Van der Eng, 2009). The origin of the collectivist society in Korea is Confucian culture, while it is the acculturation of traditional and Islamic cultures in Indonesia. Regarding the collectivist culture, Hofstede (2003) explains that the people who uphold this kind of culture tend to easily maintain human relationships, and they also tend to be friendlier toward other nationalities, leading to an ease regarding the sharing of resources including motivation. Moreover, collectivism is also characterized by the traits of interpersonal sharing, cooperation, and support (Hofstede, 2003).

Korean and Indonesian science education in the view of international studies

The quality of the general education, and specifically that of the science education, can be seen from the achievements of the students in the international assessment programs. Previously, in many of the international academic-achievement evaluations such as the Trends in International Mathematics and Science Study (TIMSS) and the Programme for International Student Assessment (PISA), Korean students have always shown outstanding levels of science achievement compared with Indonesian students. Specifically, 15-year-old students from Korea have reached the highest ranking among the OECD countries since the commencement of the PISA, and this is in contrast with the Indonesian placements that have always been in the 10th-lowest ranks since the first PISA. In the findings of the most recent PISA 2015, the Korean students placed among the fifth-highest OECD member countries and are 11th among the total of 70 countries. While the Indonesian students placed in the much lower ranking of 62nd place (OECD, 2016).

Further, in the findings of the TIMSS, Korean eighth graders showed their strong science abilities with a fourth-place achievement among the participating countries (Mullis et al., 2016). Although Indonesia did not participate in the TIMSS eighth-grader assessment, it did participate in the fourth-grader assessment. In terms of the science achievement, the quality of Korea's science education is undoubtedly high, as is suggested by the outstanding second-rank placement that was obtained by the Korean fourth-graders in the TIMSS 2015; meanwhile, the ranking of the Indonesian fourth-graders among the 47 participating countries is 44. In addition, a 20-year analysis of the TIMSS results shows that the Korean-student scientific achievement steadily improved over the period from 1995 to 2015 (Mullis et al., 2016).

The findings from the affective aspects that were obtained for both countries, however, are the opposite of the countries' scientific achievements. In the findings of the PISA 2015, regarding the science learning motivation, the average of the Korean students is lower than the averages of all of the participating countries, while one of the highest science learning motivation averages is from the Indonesian students (OECD, 2016). Similar findings were obtained from the TIMSS 2015 in terms of the topic "How much do the students like to learn science?"; that is, the Indonesian fourth-graders are in the seventh rank, with 77% of them indicating that they "very much like learning science." In contrast, the Korean fourth-graders are in the second-last rank (46 out of 47), with just 42% indicating that they like science learning, and this percentage is less than the international average of 56% (Mullis et al., 2016).

The role of country in the shaping of the student science learning motivation

Chiu and Xihua (2008) argue that country including the culture and the cultural values of particular countries contribute to the development of the student learning motivation. Moreover, they also argue that the socioeconomic statuses of particular countries also influence the student learning motivation. Based on the United Nations International Children's Emergency Fund (UNICEF), higher socioeconomic levels and gross domestic product (GDP) values positively align with the science learning motivation of a country's children (UNICEF, 2001). This finding is underpinned by the ability of richer countries to provide sufficient materials, and also more advanced materials, including books and other facilities, and these can stimulate the student learning motivation, thereby leading to a higher achievement as well. As explained by Pintrich (2003) and Urdan and Schoenfelder (2006), more effective learning environments positively contribute to the increasing of the student science learning motivation. Broadly speaking as regarding the countries as the subject of current research, Indonesian and Korea, OECD (2017) reported that Korea uses 2.3% of GDP as expenditure of their education, and this value is above the OECD's average which is 2.1%. However Indonesia only uses 1.2% of its GDP for educational funding purposes country-wide.

With respect to the culture and the cultural values that are held by the people of a particular country, Chiu and Xihua (2008) reviewed the cultural types that correlate with the learning motivation. They found that students who live in countries with egalitarian cultures and collectivist societies—the cultures that, according to Hofstede (2003),

Table 1. Dimensionality-analysis results

Country	Number of Dimensions	Final Deviance	AIC	Chi-square	df	*p*-value
Indonesia	One-dimension	56377.98	56579.98	630.84	24	0.00
	Five-dimension	**53807.76**	**54037.76**	**1938.30**	**20**	**0.00**
Korea	One-dimension	46259.16	46461.16	360.99	24	0.00
	Five-dimension	**42157.30**	**42387.30**	**641.02**	**20**	**0.00**
Both Countries	One-dimension	102790.50	102982.50	1279.84	24	0.00
	Five-dimension	**100518.89**	**100738.89**	**13852.24**	**20**	**0.00**

uphold the perception of similarity in terms of human relationships and maintain the value of sharing—tend to possess higher motivational levels and obtain higher achievements in educational contexts. Whereas, in countries that uphold an individualistic culture, the student motivation tends to be lower, leading to lower achievements. Chiu and Xihua (2008) further explain that this finding may be caused by the sharing culture, where the parents and teachers in a collectivist society attempt to support and provide for the student educational needs more than those in an individualistic culture.

RESEARCH QUESTIONS

In this paper, it is crucial to recognize that the science learning motivation does not depend solely on one variable such as country, gender, or even educational level, which is how it has been unveiled in most of the previous studies. The contributing factor of the student science learning motivation is more complex. Therefore, the following research questions were examined in the study of the science learning motivation of Indonesian and Korean secondary students:

1. Do the interactions between country, gender, and educational level exert an effect on the secondary students' science learning motivation?
2. What is the extent of the effect of the interactions between country, gender, and educational level on the associations between one motivational component and the other motivational components?

METHOD

Participants

The data regarding the middle-school and high-school students' science learning motivation were purposively collected from the two countries, Korea and Indonesia, which have different cultural and educational systems with respect to teaching and the learning of science. For this study, students who were in the second grade (8^{th}) of middle school and the first grade (10^{th}) of high school were selected as representative segments of middle- and high-school students. The totals of 867 Korean and 954 Indonesian students participated in the survey that was conducted during the years of 2015 and 2016.

Demographic data, particularly gender and educational level, were also collected from the participants. The Korean data comprises 36% of middle-school student data and 64% of high-school student data. The Korean middle-school student data comprises 55% of male-student data and 45% of female-student data, and the Korean high-school data comprises 63% of male-student data and 37% of female-student data. In terms of the Indonesian data, given the two kinds of school in the country, which are the general public school (middle school/SMP and high school/SMA) and the Islam-based school (Madrasah Aliyah/MA for high school), the data also consists of student responses from both types of school. The Indonesian data comprises 38% of middle-school student data and 62% of high-school student data. The Indonesian middle-school student data consists of 42% of male-student data and 58% of female-student data, while the high-school student data consists of 44% of male-student data and 56% of female-student data.

Instrument

Twenty-five items of the Science Motivation Questionnaire II (SMQ-II), with five levels of the Likert scale (1 = strongly disagree to 5 = strongly agree), were developed by Glynn et al. (2011) and these were utilized as the research instrument in the investigation of the student science learning motivation. The SMQ-II was selected as the research instrument because its validity has been tested by developers for both science-major and non-science-major samples; furthermore, it was also validated using the IRT–Rasch method and the classical test theory (CTT), leading the authors of the present study to believe that reliable and valid data could be obtained with the use of the SMQ-II research instrument. The SMQ-II was validated using the authors' current data, which is both the Indonesian and the Korean data, and these are provided below.

Dimensionality and item fits

The SMQ-II consists of five different constructs of the science learning motivation that assess the intrinsic motivation, career motivation, grade motivation, self-determination, and self-efficacy of a student. These five SMQ-II constructs have been statistically validated through an exploratory factor analysis that is based on the CTT method. As a complementary method, an investigation of whether the SMQ-II can be treated as one motivational construct or five constructs was also undertaken using the item response theory (IRT)–Rasch method for which a multidimensional analysis was performed. The nature of the running of the multidimensional analysis ensured that the numbers of dimensions that are present in the Korean and Indonesian data were psychometrically uncovered. As the final deviance, the Akaike Information Criterion (AIC) and the chi-square test were employed to define the goodness-of-fit model that was obtained from the multidimensional analysis including the comparison of a one-dimensional model and a five-dimensional model. The benchmarks of the lower final deviance and the AIC and the higher chi-squared distribution compared with the other comparator models were used as the indicators of the best model (Adams & Wu, 2010).

As shown in **Table 1**, the Korean and Indonesian data, and even the whole united data, were better fitted using the five-dimensional Rasch model rather than the one-dimensional model. It is suggested that the treatment of the Korean and Indonesian secondary-student SMQ-II data as five constructs would gain more valuable and meaningful results than a treatment of the data as only a single construct. The treatment of the SMQ-II as a five-dimensional instrument with the validity of every item and the reliability of every construct was also suggested. The item validity was assessed based on the mean-square (MNSQ) for which the cut-off is in the region from 0.7 to 1.4 (Wright & Linacre, 1994). Most of the item MNSQ values met the cut-off. Two items were diagnosed as misfitting items when the one-dimensional model was used for the SMQ-II data, and only one item, which is lower than 0.7 (career-motivation item-number 3), was diagnosed as a misfitting item—it can be called the "overfit item"—when the five-dimensional model was applied to the Indonesian and Korean data. According to Linacre (2012), it is not crucial that the MNSQ values that are lower than the benchmark are compared with those that are higher than the benchmark. These findings suggest that the five-dimensional treatment of the SMQ-II is more effective than the one-dimensional treatment.

Reliabilities

In terms of the reliabilities, the person and item reliabilities were obtained from the IRT–Rasch analysis. Regarding the person reliability, which is defined as the probability of the participant's consistency regarding the correct answer on every item as scaled by its difficulties (Linacre, 2012), the coefficients that were obtained from the analysis are all higher than 0.8 when the Korean and Indonesian data were run together (intrinsic motivation of 0.84, career motivation of 0.87, grade motivation of 0.85, self-determination of 0.82, self-efficacy of 0.88, and overall motivation of 0.94). According to a further interpretation of the person-reliability coefficient that is based on the research of Linacre (2012), a value of more than 0.8 provides a test that can effectively differentiate the sample into two or three levels based on the item difficulty. In addition, in terms of the item reliability, which is defined as the effectiveness of the item sample sizes that are in an accurate location on the latent variable (Linacre, 2012), all of the obtained coefficients are more than 0.95 (intrinsic motivation of 0.98, career motivation of 0.99, grade motivation of 0.98, self-determination of 1.00, self-efficacy of 0.95, and overall motivation of 0.99).

Besides the reliability analysis for which the IRT–Rasch model was used, the reliabilities for which the CTT method was used, known as the Cronbach's alpha (internal consistency of the item), also provided values of more than 0.8 (intrinsic motivation of 0.87, career motivation of 0.91, grade motivation of 0.91, self-determination of 0.84, self-efficacy of 0.91, and overall motivation of 0.96). According to Fisher (2008), the person and item reliabilities that are obtained from the Rasch analysis can also be interpreted using the alpha benchmark, and based on DeVellis (2003), an alpha that is more than 0.8 indicates a reliable instrument.

Table 2. Validity and reliability results of the SMQ II

Components		Item-fits		Person Reliability	Item Reliability	Cronbach's alpha
		Infit MNSQ	Outfit MNSQ			
Overall Motivation	Lowest	0.66	0.68	0.94	0.99	0.96
	Highest	1.45	1.48			
Intrinsic Motivation	Lowest	0.78	0.77	0.84	0.98	0.87
	Highest	1.25	1.25			
Career Motivation	Lowest	0.66	0.66	0.87	0.99	0.91
	Highest	1.24	1.23			
Grade Motivation	Lowest	0.73	0.71	0.85	0.98	0.91
	Highest	1.24	1.19			
Self-determination	Lowest	0.91	0.89	0.82	1.00	0.84
	Highest	1.13	1.13			
Self-efficacy	Lowest	0.84	0.82	0.88	0.95	0.91
	Highest	1.14	1.11			

Differential item functioning (DIF)

The *differential item functioning* (DIF) is another analysis that can be performed with the utilization of the IRT–Rasch model. Also called the item-bias analysis, it is defined as the analysis for the investigation of whether one sample group could easily agree with an item compared with other groups in the same population. The DIF was run to uncover whether the item bias occurred on the SMQ-II items for the Indonesian and Korean data. The data were divided into eight groups based on country, educational level, and gender (e.g., Indonesian-female middle school, Korean-male high school, etc.) for the running of the DIF analysis. The DIF benchmark that was suggested by Boone et al. (2014), who suggested that a DIF measurement of more than 0.64 and less than -0.64 indicated the occurrence of an item bias with a meaningful effect size, was followed for this study. The low percentage of the outage DIF measurement for which the data of this study were used indicates a low bias item.

Data Analyses

The previously mentioned dimensionality issue was addressed using the ACER ConQuest version 4.5.0 (ACER, Australia), while the investigation of the item fits and the DIF data were conducted using WINSTEP version 3.92.1. Once the IRT–Rasch analysis was performed, a set of interval-scale values, the person ability that refers to every student's abilities according to the instrumental assessment, can be obtained. The five-dimensional Rasch model was applied to the authors' SMQ-II data so that every student has five person-ability values, each of which is for each of the constructs. These person-ability values were used for a further statistical analysis.

The three-way analyses of variance (ANOVA) were performed to examine the interaction effects of country, educational level, and gender on the student science learning motivation. The three-way ANOVA was run five times, as follows: once for each type of motivation. Following the analysis that was performed to address the research-question answer regarding the different educational levels and genders of the Korean and Indonesian students in terms of the correlations between one type of motivation and the other types, the Pearson-correlation tests were performed. All of the statistical analyses as well as the Cronbach's-alpha test were run using the SPSS version 22.

FINDINGS

Comparison of the Science Motivation between the Indonesian and Korean Secondary Students

Career motivation. The mean differences between the science career motivation based country, gender, and education years are visualized in **Figure 1**. Based on the results that were computed using the three-way ANOVA analysis, significant country ($F[1, 1808] = 59.38$, $p < 0.01$, $\eta_p^2 = 0.032$) and grade ($F[1, 1808] = 11.79$, $p < 0.01$, $\eta_p^2 = 0.006$) effects were found regarding the student science-career motivation. In contrast, a significant gender effect ($F[1, 1808] = 1.02$, $p > 0.05$, $\eta_p^2 = 0.001$) regarding the student science-career motivation was not found. When the analyses were combined, a significant interaction was found between country and educational level ($F[1, 1808] = 19.78$, $p < 0.01$, $\eta_p^2 = 0.011$); but in contrast, significant interactions between country and gender ($F[1, 1808] = 0.83$, $p > 0.05$, $\eta_p^2 = 0.000$) and between gender and educational level ($F[1, 1808] = 0.39$, $p > 0.05$, $\eta_p^2 = 0.000$) were not

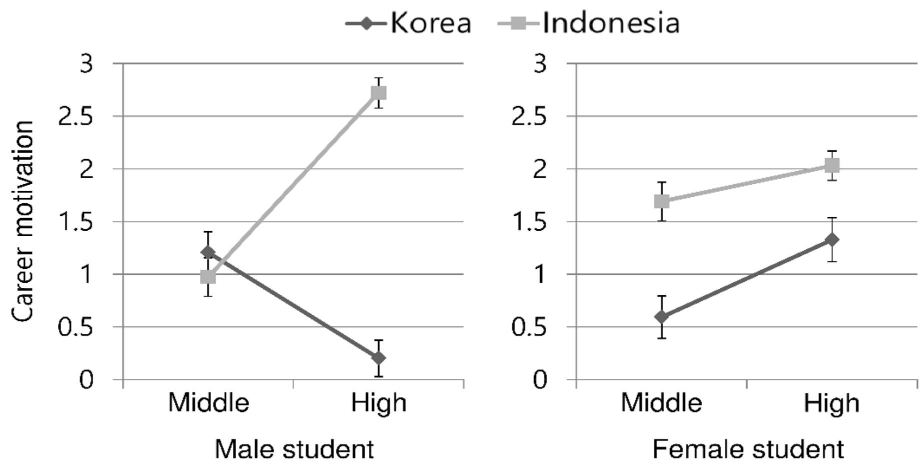

Figure 1. Comparison between Indonesian and Korean students for gender and educational level regarding the career motivation

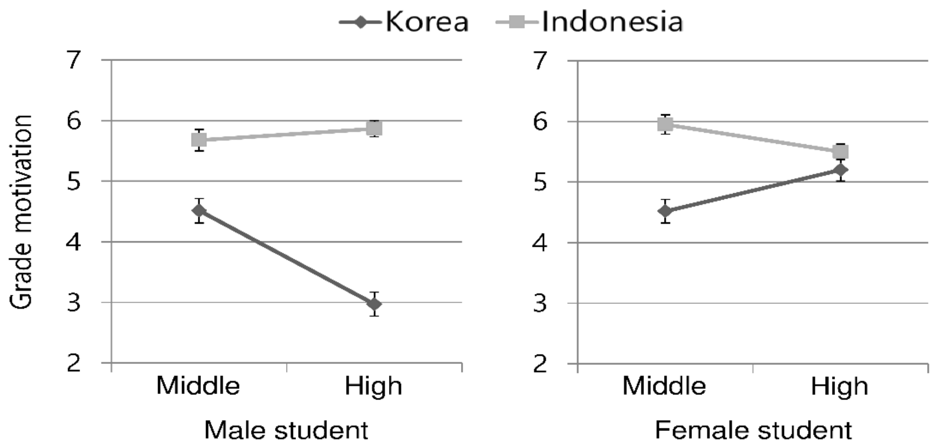

Figure 2. Comparison between Indonesian and Korean students for gender and educational level regarding the science-grade motivation

found. Lastly, a significant effect of the three-way interaction ($F[1, 1808] = 35.22$, $p < 0.01$, $\eta_p^2 = 0.019$) between country, gender, and educational level was found.

A significant interaction effect among the three group variables means that the differences between the students' career-motivation levels are affected by the combination of country, gender, and educational level rather than a single group variable. As shown in **Figure 1**, in the case of the Korean male students, the high-school students showed much lower levels of the career motivation than the middle-school students. Alternatively, the career motivation of the Indonesian male high-school students is higher than that of the Indonesian male middle-school students. The female high-school students of both countries also showed a higher career motivation than the female middle-school students.

Grade motivation. The mean differences between the grade-motivation-based country, gender, and education years are visualized in the **Figure 2**. Based on the results that were computed using the three-way ANOVA analysis, significant effects of country ($F[1, 1808] = 123.27$, $p < 0.01$, $\eta_p^2 = 0.064$), gender ($F[1, 1808] = 16.83$, $p < 0.01$, $\eta_p^2 = 0.009$), and grade ($F[1, 1808] = 4.65$, $p < 0.05$, $\eta_p^2 = 0.003$) are evident on the student science grade motivation. Significant findings were also obtained from the effects of the interaction between country and gender ($F[1, 1808] = 19.93$, $p < 0.01$, $\eta_p^2 = 0.011$) and the interaction between gender and grade ($F[1, 1808] = 9.28$, $p < 0.01$, $\eta_p^2 = 0.005$). In contrast, a significant effect from the interaction between country and grade ($F[1, 1808] = 1.32$, $p > 0.05$, $\eta_p^2 = 0.001$) was not found. Ultimately, a significant effect of the three-way interaction ($F[1, 1808] = 30.29$, $p < 0.01$, $\eta_p^2 = 0.016$) between country, gender, and educational level was found.

This result means that the differences between the students' grade-motivation levels are affected by the combination of country, gender, and educational level rather than one group variable. As shown in **Figure 2**, the

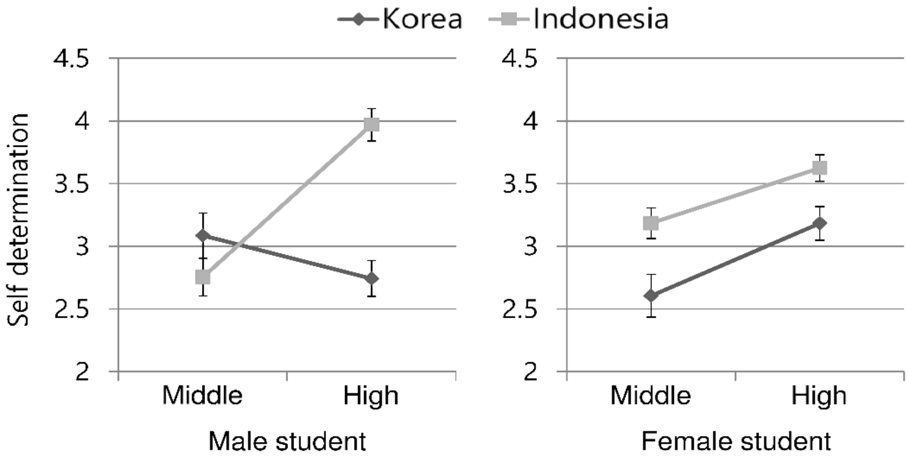

Figure 3. Comparison between Indonesian and Korean students for gender and educational level regarding self-determination

overall grade motivation of the Indonesian students is higher than that of the Korean students. Further, the grade motivation of the Korean male high-school students is much lower than that of the middle-school students. Meanwhile, the grade motivation of the Korean female high-school students is higher than that of the middle-school students.

Self-determination. The mean differences between the self-determination-based country, gender, and education years are visualized in **Figure 3**. According to the results that were obtained from the three-way ANOVA analysis, significant effects of country ($F[1, 1808] = 20.87$, $p < 0.01$, $\eta_p^2 = 0.011$) and grade ($F[1, 1808] = 20.30$, $p < 0.01$, $\eta_p^2 = 0.011$) were found regarding the science learning self-determination, but a significant gender effect is not evident on the secondary-student self-determination ($F[1, 1808] = 0.01$, $p > 0.05$, $\eta_p^2 = 0.000$). As well as the absence of a significant gender-based finding, significant effects of the interaction between country and gender ($F[1, 1808] = 0.09$, $p > 0.05$, $\eta_p^2 = 0.000$) and between gender and educational level ($F[1, 1808] = 0.12$, $p > 0.05$, $\eta_p^2 = 0.000$) are not evident; however, a significant effect of the interaction between country and educational level ($F[1, 1808] = 11.49$, $p < 0.01$, $\eta_p^2 = 0.006$) was found. Lastly, a significant effect of the three-way interaction ($F[1, 1808] = 16.35$, $p < 0.01$, $\eta_p^2 = 0.009$) between country, gender, and educational level is evident.

This result means that the differences between the self-determination levels of the students are affected by the combination of country, gender, and educational level rather than one group variable. The overall differences between the self-determination levels according to the combination of the group variables show a pattern that is similar to that of the career motivation. As shown in **Figure 3**, in the case of the Korean male students, the high-school students showed a lower level of self-determination than the middle-school students. Alternatively, the self-determination of the Indonesian male high-school students is much higher than that of the Indonesian male middle-school students. The female high-school students of both countries also showed higher self-determination levels than the female middle-school students.

Self-efficacy. The mean differences between the self-efficacy-based country, gender, and education years are visualized in **Figure 4**. Based on the results that were computed using the three-way ANOVA analysis, a significant country effect ($F[1, 1808] = 154.01$, $p < 0.01$, $\eta_p^2 = 0.078$) was found for self-efficacy, but in contrast, a significant effect ($F[1, 1808] = 2.13$, $p > 0.05$, $\eta_p^2 = 0.001$) is not evident for the gender and the grade in terms of the self-efficacy ($F[1, 1808] = 1.36$, $p > 0.05$, $\eta_p^2 = 0.001$). Similarly, significant-effect findings were not obtained from the interactions between country and gender ($F[1, 1808] = 0.47$, $p > 0.05$, $\eta_p^2 = 0.000$) and between country and educational level ($F[1, 1808] = 0.09$, $p > 0.05$, $\eta_p^2 = 0.000$). By contrast, a significant effect of the interaction between gender and grade ($F[1, 1808] = 4.93$, $p < 0.05$, $\eta_p^2 = 0.003$) was found. Lastly, a significant effect of the three-way interaction between country, gender, and educational level ($F[1, 1808] = 15.13$, $p < 0.01$, $\eta_p^2 = 0.008$) was found.

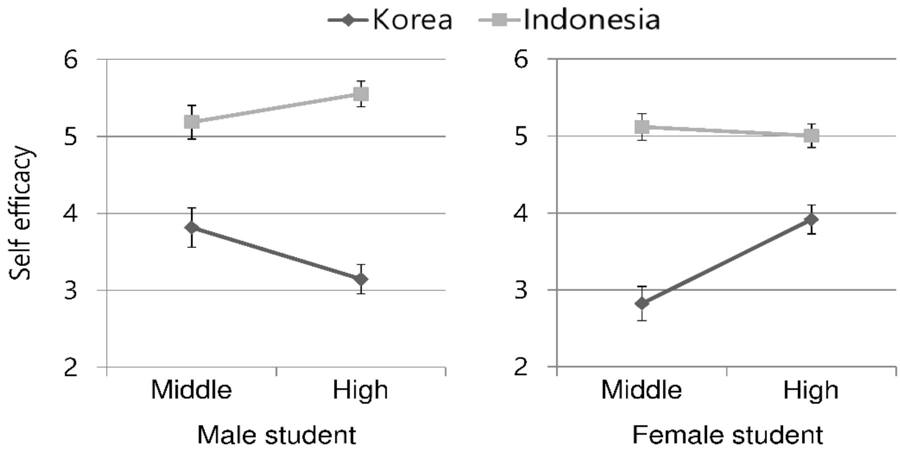

Figure 4. Comparison between Indonesian and Korean students for gender and educational level regarding self-efficacy

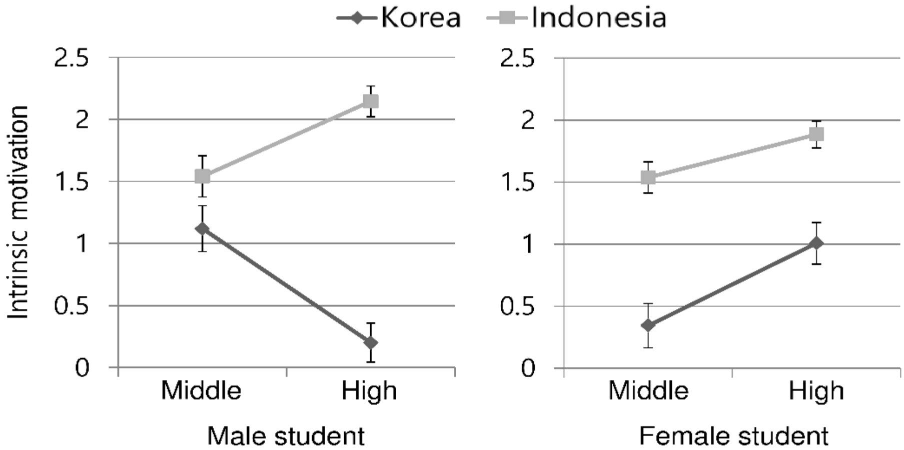

Figure 5. Comparison between Indonesian and Korean students for gender and educational level regarding intrinsic motivation

This result means that the differences of the self-efficacy levels of the students are affected by the combination of country, gender, and educational level rather than one group variable. As shown in **Figure 4**, the overall self-efficacy of the Indonesian students is higher than that of the Korean students, and only slight differences in the self-efficacy levels according to gender and educational level are evident. The self-efficacy of the Korean male high-school students is lower than that of the middle-school students, and the self-efficacy of the Korean female high-school students is higher than that of the middle-school students.

Intrinsic motivation. The mean differences between the intrinsic-motivation-based country, gender, and education years are visualized in **Figure 5**. Based on the results that were obtained from the three-way ANOVA analysis, a significant effect of country (F[1, 1808] = 97.49, $p < 0.01$, $\eta_p^2 = 0.051$) was found; but in contrast, significant effects of gender (F[1, 1808] = 0.28, $p > 0.05$, $\eta_p^2 = 0.000$) and educational level (F[1, 1808] = 2.38, $p > 0.05$, $\eta_p^2 = 0.001$) are not evident when they are separately examined. A significant-finding effect is also absent in the interaction between country and gender (F[1, 1808] = 0.44, $p > 0.05$, $\eta_p^2 = 0.000$), whereas significant effects occurred in the interactions between country and educational level (F[1, 1808] = 7.19, $p < 0.01$, $\eta_p^2 = 0.004$) and between country and gender (F[1, 1808] = 8.70, $p < 0.01$, $\eta_p^2 = 0.005$). Lastly, a significant effect of the three-way interaction between country, gender, and educational level (F[1, 1808] = 16.75, $p < 0.01$, $\eta_p^2 = 0.009$) is evident.

This result means that the differences of the students' intrinsic-motivation levels are affected by the combination of country, gender, and educational level rather than one group variable. As shown in **Figure 5**, the pattern of the difference of the overall intrinsic motivation according to the combination of the group variables is similar to those of the career motivation and the self-determination. The Indonesian students showed a relatively higher intrinsic motivation than the Korean students, and in the case of the Korean male students, the high-school students showed a much lower intrinsic motivation than the middle-school students. Alternatively, the self-determination of the Indonesian male high-school students is much higher than that of the Indonesian male middle-school students. The

Table 3. The summary of the results of three-way ANOVA

Motivation components	Interaction effects *	Effect size (η_p^2)
Career motivation	Significant**	0.019
Grade motivation	Significant**	0.016
Self-efficacy	Significant**	0.009
Self-determination	Significant**	0.008
Intrinsic motivation	Significant**	0.009

*interaction between country, educational level and gender, ** $p < 0.01$

Table 4. Pearson correlation coefficients (all correlations are significant at 0.01)

		Korea				Indonesia			
		Middle		High		Middle		High	
Variables		Male	Female	Male	Female	Male	Female	Male	Female
Career motivation	Grade motivation	0.456	0.225	0.462	0.423	0.154	0.243	0.249	0.244
	Self-determination	0.524	0.514	0.407	0.329	0.144	0.256	0.186	0.127
	Self-efficacy	0.520	0.448	0.507	0.434	0.179	0.178	0.129	0.107
	Intrinsic motivation	0.618	0.621	0.610	0.634	0.300	0.279	0.125	0.132
Grade motivation	Self-determination	0.587	0.241	0.460	0.402	0.259	0.245	0.342	0.275
	Self-efficacy	0.572	0.299	0.573	0.436	0.171	0.278	0.173	0.215
	Intrinsic motivation	0.462	0.208	0.504	0.295	0.158	0.190	0.223	0.129
Self-determination	Self-efficacy	0.799	0.666	0.676	0.658	0.251	0.361	0.165	0.275
	Intrinsic motivation	0.702	0.645	0.529	0.442	0.341	0.346	0.258	0.220
Self-efficacy	Intrinsic motivation	0.682	0.624	0.605	0.540	0.340	0.276	0.267	0.240

self-determination levels of the female high-school students of both countries are also higher than those of the female middle-school students.

Table 3 provides a summary of the statistical findings of the interactions between country, educational level, and gender throughout all of the components of the science learning motivation.

Correlational Differences among the Science Motivational Components of the Indonesian and Korean Students

As shown in Table 4, all of the motivational components are significantly correlated ($p < 0.01$) with one another in both the Indonesian and Korean samples for which the gender and the educational level were varied. In the comparison of the correlation coefficients among the male samples, both the Indonesian middle- and high-school students showed a weaker association between one component and another compared with the Korean middle- and high-school students. For the Indonesian middle-school students, the lowest coefficient was the correlation between the career motivation and the self-determination ($r = 0.144$), whereas the highest correlation was between the self-determination and the intrinsic motivation ($r = 0.341$). For the Indonesian high-school students, the lowest coefficient was the correlation between the career motivation and the intrinsic motivation ($r = 0.125$), whereas the highest correlation was between the grade motivation and the self-determination ($r = 0.342$). In terms of the Korean middle- and high-school students, the lowest and highest correlations were those between the career motivation and the grade motivation ($r = 0.456$) and between the self-determination and the self-efficacy ($r = 0.799$), and those between the career motivation and the self-determination ($r = 0.407$) and between the self-determination and the self-efficacy ($r = 0.676$), respectively.

Similar findings were also found in the female-sample pools, where the educational levels of the Indonesian students were lower than those of the Korean students. Among the Indonesian middle- and high-school students, the lowest and highest associations were the correlations between the career motivation and the self-efficacy ($r = 0.178$) and between the self-determination and the self-efficacy ($r = 0.361$), and those between the career motivation and the self-efficacy ($r = 0.107$) and between the grade motivation and the self-determination ($r = 0.275$), respectively. For the Korean middle- and high-school students, the lowest and highest associations were the correlations between the career motivation and the grade motivation ($r = 0.225$) and between the self-determination and the self-efficacy ($r = 0.666$), and those between the grade motivation and the intrinsic motivation ($r = 0.295$) and between the self-determination and the self-efficacy ($r = 0.658$), respectively. Overall, the Indonesian-student correlation coefficients are much lower than those of the Korean students.

DISCUSSIONS

The current study demonstrates the interactions between the three most significant contributing factors regarding the student science learning motivation, as follows: country, gender, and educational level. The effects of these three factors on the associations among the science motivation components were also examined. This section will discuss the findings in two parts, one for each research question.

Effect of the Interactions between Country, Gender, and Educational Level on the Student Science Motivation

In response to the first research question that is addressed in this paper, the combination of country, gender, and educational level significantly define the student science learning motivation. Looking out in a more detail to the results of the five science motivational components, the current research has found two distinct patterns on the Indonesian samples, while the Korean samples showed the same pattern in all of the motivational components. As seen in visualizations of the results for all motivational components (**Figure 1** to **5**), the Korean samples showed that male students tended to have declining trends from middle school to high school students while female student's motivational components were prone to be increasing from middle to high school. The two patterns showed in the Indonesian samples were only exhibited as well in the female samples. The male samples had increasing trends in all motivational components, while the female students had only increasing trends in the career motivation, self-determination and intrinsic motivation. Interestingly, the results from the two other factors showed a stable-slightly-decreasing pattern from middle to high school level; these patterns are contrary to the results from Korean female students. In the overall assessments, the Indonesian male and female students slightly showed a quite non-extreme difference in all motivational components, while the identified Korean male and female students showed very different trends.

These findings could address what Bybee (2012) found in the PISA 2006 regarding the inconsistency of the student science learning motivation that varied between countries and also according to gender in particular countries. In addition, these findings can also be used as a response to the paper of Osborne et al. (2003), wherein it is stated that the attitudes in science including the science learning motivation are nebulous and are often not well understood. With the findings that have been obtained in this paper, we believe that the science learning motivation is indeed nebulous, and the findings are also inconsistent because the sole focus of most of the previous studies that investigated the student science learning motivation is merely the separate investigation of those three variables; that is, just country or culture or gender, or even just a specific level of education (e.g., Vedder-Weiss & Fortus, 2012; Zeyer, 2018; Zeyer et al., 2013). Even international studies like the PISA and the TIMSS have not discussed or examined the interactions between all the three factors, as they have just used two of the three variables, country and gender.

Based on the findings, it is assumed that the interactions between the three factors occur as a part of a student motivational system. The authors believe that the societies of the world's countries, each with a unique and specific culture, treat every gender type differently. A type of treatment is the stereotypical perception of a particular society that science is a more masculine subject (Meece et al., 2006) such as in Korea (Narayan et al., 2013; OECD, 2016; Song & Kim, 1999) and this result in the application of a strong pressure on male students to enroll in science subjects and pursue science-related careers. In fact, economically it is noted that Korea as a developed country comprises of many people working in the science-related fields leading to the low rate of job vacancy in the fields, also the increased difficulty level of science contents from middle to high schools taught with advanced science teaching and learning activities (such as the Research and Education or R&E program), may contribute to the decreasing trends of Korean male students with a science learning motivation, as found in the results of current research. As the job issues may be the cause of the decreasing trend of Korean male student's career motivation, perhaps it also impacts their grade motivation as they are likely to not have the intention of obtaining a higher grade in a science subject. Moreover, R&E programs infused in Korean science education is a program providing high school students to be engaged in more advanced science learning activities, such as experimenting, taken place in the nearest university labs and advised by the university's professor. Perhaps, this kind of program is taken in a more serious way leading to a loss of 'fun' activities in learning science that could decrease the student's science interest, in which an important aspect for a student to be more intrinsically motivated, self-determined and having more confidence or self-efficacy in learning science. As Jack and Lin (2017) argue that intriguing science classes are the most crucial concepts necessary to appeal to students to have more interest in science leading to producing more intrinsically motivated students.

It is noted that in comparison to the Korean male students, its female students had shown increasing trends in all motivational components. Along with the higher educational levels they were showed to be more extrinsically and intrinsically motivated, self-determined and confident individuals. We are assuming what made Korean female students were found different to the male students is perhaps that they are not much impacted by the 'masculinity' perspective of science, so that they do not have much pressure and anxiety in learning science, and they may feel more comfortable to learning it without any demand of excelling in this particular subject from their parents, teachers and/or society. This may lead to make them a more intrinsically motivated individual. As Zeyer (2018) assumes that once students are becoming more intrinsically motivated individuals, they tend to have more interest and curiosity in higher or advanced level of science contents, thinking and/or learning activities, including the R&E program. Moreover, as the response to the UNESCO's report (UNESCO, 2015) regarding Korea as one of the lowest equity of gender-based statistics as associated in science-related careers, which are still dominated by males, the Korean government now is attempting to reduce this low gender equity labelling by increasing the number of women working in the science-related fields through the various policies and campaigns for women in fields of science and technology such as 'Women Into Science & Engineering (WISE)' from 2002 (Lee, 2012). The campaign may potentially contribute to the attracting of Korean female students to pursuing jobs in science-related fields, and as found in a current study of Korean female students that this effort had an increasing trend in the science careers and the student's grade motivation.

In terms of the findings from the Indonesian male students, the Indonesian male students were found on the opposite trends with the Korean male students for all motivational components. It is noted that the Indonesian male students had increasing trends in the five motivational components, along with the higher level of education. Perhaps this is caused by the label of developing country that Indonesia has had to date. Indonesia now is trying to put much effort into increasing the number of individuals working in the science-related fields, thus it provides more job vacancies with higher salaries that appeals to both Indonesian male and female students, when it is time for them to go out pursuing their jobs after graduation. Moreover, more than two centuries of Indonesian people have brought gender equality as an important concept in various aspects of life (Martyn, 2005), and it has resulted with the negligible gap or quite an equal number of both genders working in science-related jobs (UNESCO, 2015). This gender equality movement is likely to decrease the impact of the masculinity assumption that science subjects are perceived. However, gender bias may also still exist, as a current research found female students tended to have a decreasing trend in grade motivation and self-efficacy along with their educational levels. The science contents in Indonesian science curriculum may be considered as one of the causes. In Indonesia, the high school science contents tend to be more cognitive challenging than those in middle school level, and as Zeyer (2018) stated that male students are prone to be more attracted to the cognitive challenging concepts which are leading to be more active in science class and better at gaining the attention from the teachers, which allows them to earn a higher grade. As male students are more skilled at gaining more attention from the instructor in the classroom, it may impact female students to realize that they may not be able to obtain higher grade in more challenging science class and will thereby serve to decrease their self-efficacy or confidence to become a success in the challenging nature of a science class. However, it should be emphasized that the differences were quite low.

Taken altogether and reviewing the interpretations, what has caused Indonesian male-female students in the high school level to be superior in their five science learning motivational-based components than the Korean male-female students? We believe the impact of the 'fun' rate and the society pressure are the causing this significant differences among the students. As previously mentioned, it is noted that Korean science classes are mainly more challenging and more advanced, like an R&E program which has less 'fun' on the application, together with 'Education Fever' in the Korean society and pressure to get a high score in the college entrance exam for gaining an advantage for enrollment to prestigious universities have impacted their motivation to learn science and could not exceed the Indonesian student's motivation to learn science. In Indonesia, science is still taught traditionally, where observations of the surrounding environment and the Indonesian biodiversity context are used, and therefore, more learning activities occur outside the classroom and this is of greater interest to the students. Also, Indonesian parents, teachers and society are not heavily putting pressure onto students to get into the highest quality ranked universities. This has resulted in the phenomenon of a noted higher science motivation that Indonesian students had as compared to the motivation noted with the Korean students. Furthermore, as most Indonesian science classrooms are currently still likely using traditional methods of teaching, even though it could elevate the impetus of the student's science learning motivation, it is noted that the effort fails to increase scientific literacy for those students in that case. The Korean situation as noted in the classroom is likely to be considered the opposite scenario, and it could be noted to increase the student's associated scientific literacy, but not their science motivation.

Based on the idea of making sense of the current research's findings, we believe that refinement in the society and science curriculum may be taken as the important effort to manage the concept that will work towards aligning scientific literacy level and motivation for the students to want to learn about science in the classroom. The results from these two countries, Indonesia and Korea, suggest that putting less pressure to both genders by not labelling science subjects as a traditional masculine subject, giving attention equally, having a more 'fun' science class, but still not losing the basic scientific literacy competencies, may be considered as the effort that may work to achieve the goal to have a higher motivation to learn science. By taking into account the interactions of the three factors, this study found the patterns of motivation that are distinguished by the combination of these factors. These distinctive patterns mean that some science teaching-learning strategies that are suggested globally as seen and noted as an effective way to improve science learning motivation, but these strategies cannot work for each student identically in the classroom, and for that reason the science educator needs to consider the student's motivational characteristics with noting the complexity of the class being taught. However, we also want to emphasize here that we discuss the interactions between the three factors as correlational, and one concept which is one factor impacting another factor and also impacting another, given that it is quite difficult to discuss all factors together by using only our obtained statistical data. Thus, we are aware of this issue as part of the limitation of the current research.

Differences of the Science Learning Motivation Structure between Indonesian and Korean Secondary Students

A correlation test was used to formulate a response that addresses the second research question regarding the structural differences between the Indonesian and Korean secondary-student science learning motivations, and for the identification of these differences as one of the direct effects of the interactions between the three previously mentioned variables. The direct effect of the interactions between those three variables on the student science learning motivation was suggested by the findings of the Pearson-correlation tests that are presented in **Table 4**. Even though, based on the findings of **Table 4**, the motivational levels of both the male and female Indonesian students in middle school and high school are higher than those of the Korean students, the correlation between one of the motivational components and the others were much weaker than that of the Korean students. It is suggested that when the Indonesian students show a high value in one motivational component, the values of the other components are not high. In contrast, if the value of one of the motivational components is high for the Korean students, they might also show high scores in the other components. These findings could also be considered as a result of the motivational complexity.

The present findings suggest that a high science learning motivation does not exactly define the structural stability of every component so that they are highly correlated with one another. The weak correlation that is exhibited in the Indonesian sample suggests that the motivation to learn science cannot be assumed as one latent variable, and that a different sample type can produce more than one latent motivational variable. The complexity of the science learning motivation, as well as the treatment of the dimensionality of the motivational instrument, is crucial for the attainment of a more meaningful outcome and to uncover the vagueness of the student science learning motivation.

CONCLUSIONS

In brief, unlike the previous study that simply compared the science learning motivation in terms of particular variables, such as the sole consideration of gender, the significance of this study is the unveiling of the complexity of the interactions between the following three factors that provide the greatest contributions regarding the student science learning motivation: country, gender, and educational level. With the use of statistical evidence, the current work has found that the process for the defining of the student science learning motivation is more complex than that of the previous conception. The interactions between the different kinds of culture in particular countries that treat every gender differently, and the impact on the curriculum and the teaching practices at the different educational levels, means that the defining of the student science learning motivation is not a straightforward matter.

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Exploring Students' Engagement Patterns in SPOC Forums and their Association with Course Performance

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ABSTRACT

With the popularity of Small Private Online Courses (SPOCs) in higher education, a plentiful of discussion data has been increasingly generated in SPOC forums. With 752 undergraduates' discussion posts, this study aims to investigate students' engagement patterns within SPOC forums in terms of engagement behaviors and emotions. Firstly, we designed a behavioral code rule to identify posting- and content-level behaviors, and examined their association with course performance. Secondly, we built an emotion lexicon including positivity, negativity and confusion word sets, and adopted an emotion calculation approach to visualize emotional evolutionary trends and to examine emotional differences in registration types and course performance. The results show that, (1) the high-performing group was more active in the most engagement behaviors except for interactive postings. (2) The registered group delivered more threads and wrote richer vocabulary in post content. (3) Whether students were registered for a course or not did not have a significant effect on their emotional expressions, but the registered group exhibited more confusion in forum interactions at the end of the semester. (4) Positive emotion was prevailing for the entire population. Furthermore, compared with the low-achieving group, the high-performing group had higher emotion densities in three types of emotions.

Keywords: Small Private Online Course (SPOC), computer-mediated communication, engagement behavior, emotion density, learning performance

INTRODUCTION

In the past two decades, the tremendous development of information and communication technologies has promoted the innovation of teaching and learning modes in higher education. As a variant of Massive Open Online Course (MOOC), the Small Private Online Course (SPOC) is being universally used to serve on-campus students in formal education (Cheng, Liu, Sun, Liu, & Yang, 2017; Combéfis, Bibal, & Van, 2014; Liu, Cheng, Liu, & Sun, 2017). The SPOC mode has been verified effective for improving performance of students in engineering courses (Fox, 2013; Piccioni, Estler, & Meyer, 2014; Zhang, Zhu, Zou, Yan, Hao, & Liu, 2015). Unlike MOOCs, SPOCs facilitate the adoption of blended learning modes, which combines self-paced learning with supervised instructional strategies (Rooney, 2003; Ward & LaBranche, 2003). In blended learning modes, SPOCs can assist teachers to observe and guide learners as a supplement to face-to-face classrooms where individual learning data are difficult to be recorded (Cheng et al., 2017; Kaplan & Haenlein, 2016; Kim, 2007).

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Contribution of this paper to the literature

- The purpose of this study aims to explore how students interact in SPOC forums and the engagement patterns behind different registered groups and different performing groups.
- This study indicates that, the registered group tends to be more active in delivering thematic posts than the non-registered group. There is not a significant emotional difference between registered and non-registered groups. However, the registered students had a higher level of confusion at the end of the semester.
- The study indicates that the high-performing group performed more actively in most engagement behavior categories except for interactive postings, and exhibited higher emotion densities across a semester.

Student' Engagement in Course Forums

In SPOC-supported courses, discussion forums are commonly used as a crucial component in blended learning, and as the primary information exchange channel among students and their teachers. The increased use of SPOC forums has contributed to the generation of massive interactive data in higher education. Within the forum data, the hidden engagement patterns involving interactive behaviors and emotional states have been considered as critical factors indicating learning performance (Kent, Laslo, & Rafaeli, 2016; Phan, McNeil, & Robin, 2016; Qiu et al., 2016; Tucker, Pursel, & Divinsky, 2014; Yang, Kraut, & Rosé, 2016; Yang, Wen, Howley, Kraut, & Rose, 2015). Especially, interactive postings and average depth in threads were considered to be correlated with examination' grades (Kent et al., 2016). During discussion postings, students' positive emotion was connected to a good quiz performance (Tucker et al., 2014), and confusion and negative emotions had detrimental effects on their learning outcomes (Wen, Yang, & Rosé, 2014; Yang et al., 2015). Therefore, the engagement patterns in discussion forums are quite critical for identifying at-risk students in formal learning and improving their learning performance. Nevertheless, as for SPOC forums, the association between the latent engagement patterns and learning performance is still unclear and needs to be explored.

Research Purpose and Questions

As a reflection of student learning experience in discussions, a variety of discourse behaviors could be explored through forum posts, such as interactive postings between peers (Chiu & Hew, 2018), exchanges of learning feelings (Ramesh, Kumar, Foulds, & Getoor, 2015; Wen et al., 2014), expressing opinions (Ekahitanond, 2014; Liu, Zhang, Sun, Cheng, Peng, & Liu, 2016), etc. To get some insights of students' engagement in SPOC forums, we will explore students' engagement patterns in forum discussions in terms of two major factors: behavior and emotion. In MOOC contexts, the relationship between engagement behaviors and learning effects has been investigated in prior work (Wang, Yang, Wen, Koedinger, & Rosé, 2015), and the association between emotions and summative course completion has been assessed as well (Wen et al., 2014). But few studies have been conducted to unfold the engagement patterns in a restricted private course platform and connect them to final performance in degree courses. The aim of this work is to investigate the engagement patterns of college students in SPOC forums in terms of the behavioral patterns and emotional states, and their association with learning outcomes. Specifically, there are four questions to be addressed in this study:

Question 1: What engagement behaviors in SPOC forums are associated with higher course performance?

Question 2: What differences exist between engagement behaviors of registered students and non-registered students?

Question 3: What are evolutionary trends in emotional states of the registered and non-registered students, and what differences exist between them?

Question 4: What are evolutionary trends in emotional states of high- and low-performing students, and what differences exist between them?

LITERATURE REVIEW

Online discussion forums enable students to deliver feedback, discuss knowledge and skills, consult peers about questions emerged in learning, as well as facilitate students to form a sense of community that connects them to courses (Hollands & Tirthali, 2014). Recently, an extensive research focuses on engagement patterns within course forums and their relationship with learning effects. These concerns can be divided into two aspects, such as engagement behaviors and emotion states in interactions.

Engagement Behaviors of Students in Course Forums

Engagement behavior is a critical indicator to identify the level of knowledge construction, affecting the ultimate academic achievement. Some existing research has implied a positive correlation between engagement in discussions and learning outcomes (Kent et al., 2016; Wei, Peng, & Chou, 2015). Especially, posting behaviors in MOOC forums have been considered a crucial predictive indicator to course completion or dropouts. Goldberg et al. (2015) explored that completers engaged in significantly more discussion posts than non-completers across all levels of education in a MOOC, but this study only investigated total number of postings instead of fine-grained engagement behaviors like asking questions, expressing opinions, etc. To obtain in-depth insight on engagement patterns, Tella & Isah (2011) designed a questionnaire to identify four prominent types of engagement behaviors in a university discussion forum, such as questioning, reaction posting, sharing of personal opinion and experiences and brainstorming. Cerezo et al. (2016) extracted some engagement variables such as active time spent in forums and problem-solving tasks, as well as number of words in posts to represent students' performance in course forums. In their study, the number of words in posts were considered as an index of the effort invested by students and found to be positively related with final marks. Anderson, Huttenlocher, Kleinberg, and Leskovec (2014) characterized students' engagement by connecting their assignment submissions to the discourse content within their postings, and they found that, the number of terms involving course terminology in forums was significantly correlated with the times of assignments' submissions. Liu et al. (2018) categorized the postings into interactive, registering, questioning, viewpoint, thematic and quoting behaviors. This study yielded that there were significant differences between high- and low-achieving groups in the former 5 behaviors, with the behavior most correlated to course performance being the questioning posting. Besides, by a content analysis approach based on cognitive science, Wang et al. (2015) identified three types of latent engagement behaviors (active, constructive and interactive) from forum conversations, in which active and constructive discussion behaviors were significantly related with students' learning gains, while interactive discussion behaviors could significantly predict learning gains only for inactive students in forums.

Unlike engaging with MOOCs, learners in SPOCs generally need to use their real identities to register for a course (Guo, 2017), and learners in a course may be quite familiar with each other since they typically come from one university or even a class with the same educational background. If engagement behaviors hidden in SPOC forums could be sufficiently extracted and investigated, the university administrators and course instructors could have more opportunities to reveal the latent reasons why some students perform well or not in blended learning.

Emotional States of Students in Course Forums

Separation of time and space in online learning contexts hinders the transmission of academic emotional information. In this case, it is difficult for instructors to identify the struggling, confused and even frustrated students. Previous research has indicated that positive emotion helps to promote students' learning interests and engagement levels (Altrabsheh, Cocea, & Fallahkhair, 2015; D'Mello et al., 2008), and students with an upsurge of emotion may have higher motivation to accomplish their learning goals. Ramesh, Goldwasser, Huang, Daumé III, & Getoor (2013) incorporated the positive/negative score of post content into engagement metrics to distinguish between disengaged and engaged learners in MOOC forums. They found that engaged learners had a higher performance score, but there no a significant difference between disengaged and engaged learners in terms of negative sentiment of post content. To explore emotional evidence behind MOOC dropouts, Wen et al. (2014) calculated the sentiment rate over time on posts and inferred the potential correlation between temporal sentiment rates (positivity/negativity scores) and student survivals. Chaplot, Rhim, and Kim (2015) incorporated the emotional scores of posts into a neural network to predict student attrition in MOOCs. The joint modelling of emotion and topics has drawn increasing attention on capturing latent emotional feedback and requirements during the processes of problem-solving (Liu et al., 2016; Ramesh, Dan, Huang, Daume, & Getoor, 2014; Ramesh et al., 2015). Besides, confusion has been viewed as an emotion to infer students' potential difficulties and final learning performance in online learning. The indicators of confusion in conversational cues have considered as a viable solution to detect students' confusion in interactive learning environments (Arguel, Lockyer, Lipp, Lodge, & Kennedy, 2017). Liu, Pataranutaporn, Ocumpaugh, and Baker (2013) claimed confusion might evolve into frustration and negative emotion when it could not be regulated appropriately. The students would be less likely to discuss course content if they were often exposed to confusion. Yang et al. (2015) utilized a collection of features (click behaviors, linguistic features and question features) to construct a classification model to automatically identify posts with confusion, and revealed that the more students showed their confusion in forums, the lower the probability of their continued participation in courses.

These studies have investigated plentiful regularities in MOOC forums, but quite few research focuses on automatically mining engagement patterns in SPOC forums. With increasing popularity of SPOCs in high education, the forum data needs to be sufficiently utilized to help instructors understand how students interact

Table 1. Statistics of the two SPOC forums in Psychology Foundation course

Course No.	Students	Total weeks	Posts per week	Total posts	Total threads	Total notional words	Total sentences
PF1	591	22	457	10,054	2,024	455,210	85,203
PF2	161	18	45.33	816	221	48,625	9,164

with peers in this type of restricted learning context and what engagement patterns are associated with course performance.

MATERIALS AND METHODS

Participants

The data in this study is derived from two discussion forums of the *Psychology Foundation* degree course, which is a major course of science education within a primary and secondary teacher training programme. The forums are set in a SPOC platform issued by a Research and Development team at a Normal university of Central China (http://moocapp.starc.com.cn/application/mooc/). It is worth to note that SPOC forums are employed as a supplement to face-to-face instruction in regular teaching.

The collection and analysis of the data has obtained the permission of students and administrators in the university, and the personal identity information has been anonymized in this research. A total of 10,870 posts were delivered by 752 undergraduates across two semesters, such as the first and second semesters of academic year 2014-2015. The posters include 719 registered students in this degree course and 33 non-registered students who are only voluntary participants but do not need to gain credits of this course. Statistics on the two course forums are shown in **Table 1**. The average score of the registered students was 75.97 (on a scale of 0-100) with a variance of 13.87. Students' scores in the final exam were used to represent their course performance. The final exam aimed to evaluate a student's mastery of the psychological knowledge, skills and abilities to analyse actual problems. Thus, the evaluation did not consider students' engagement in the forum, which makes sense to investigate the potential association between perform engagement patterns and course performance.

Study Design

This study aims at exploring how students engage in discussions in SPOC forums with behavior analysis and emotion calculation approaches. In the first step, inspired by the study of Wang et al. (2015), we will formulate a behavioral code rule, and automatically identify engagement behaviors within each post by this coding rule. These behavioral variables include the explicit posting behaviors like launching threads, following a thread as well as the implicit behaviors like asking questions, expressing opinions. Furthermore, we count the content-based statistical variables such as number of sentences, notional words and average notional words per post for each participant. The association between behavioral variables and course performance will be analysed. In the second step, we will adopt an emotion density calculation criterion to quantify emotions within post content in terms of positivity, negativity and confusion, as well as explore temporal emotional trends of different performing groups and emotional differences between them. The detection and calculation of engagement behaviors and emotional states are implemented in the Java programming environment ECLIPSE 8.5, and the correlation analysis and difference examinations are conducted in MATLAB 2017's statistic toolbox.

It is worth to note, in order to divide the groups with different levels of course performance, the High-Low Discrimination index proposed by Kelley (1939) is adopted to determine the high- and low-performing individuals in terms of the top 27% and bottom 27% of final scores, respectively. In this way, we divide the students in each forum into the high-, medium- and low-performing groups. Then the corresponding groups of PF1 and PF2 forums are merged. Thus all registered participants (N=719, PF1: N=567, PF2: 152) in "Psychology Foundation" course forums are divided into the three groups, such as high-performing group (N=187, PF1: N=150, PF2: 37), the low-performing group (N=190, PF1: N=152, PF2: 38), and the medium-performing group (N=342, PF1: N=265, PF2: 77) which will be not further analysed for simplicity.

Behavioral Coding Rule

Posting-level behaviors

Through the content analysis (De Wever, Schellens, Valcke, & Van Keer, 2006) on the forum data, we summarize five primary types of engagement behaviors covering 100% of posts. To ensure the accuracy of coding, taking randomly selected 50% of posts as baseline samples, we initially invite two coding experts from instructional

Table 2. Coding rule of posting-level behaviors

Code	Behavioral variable	Description	Example
LT	Launching a thread	Launch a discussion theme (involving popular topics, unsolved problems, critical knowledge points, etc.) to promote the problem-solving and idea-sharing and knowledge-understanding among students.	请列举生活中潜在性学习的例子/Please enumerate examples of potential learning in life.
FT	Following a thread	Regularly follow a thread to engage in discussions, suggesting a follower only reply the initiator of the thread instead of other followers in a thread.	比如我经常读一些历史书籍，只是因为感兴趣，但是我发现，在写作时会不时地用到书中的知识/For example, I often read some history books, just because of interests, but I found that I may occasionally use the knowledge in books in writing.
IP	Interacting with peers	Mention or assist peers on a topic with keywords like “reply”, “mention” or “@” in titles or content of posts.	@2013213XXX，人都是多面的，他们只是把自己的另外几面放大了/People are multi-faceted, they just magnified their other faces. (Note: 2013213XXX is student ID).
DT	Depth in a thread	Average number of followers under a contributed thematic post which implies attractiveness of topics launched and influence of a topic sponsor.	N/A
RP	Registering personal information	Register personal attendances in forum with the requirement of instructor, keywords include “report”, “I am”, student’ name and ID, etc.	老师好，我是XXX，我的课堂号是24，学号203210XXX/Hello, I am XXX, my class number is 24, student ID is 203210XXX.

technology to design the coding rule by manually identifying behaviors within the samples. Then we invite three researchers in learning analytics to jointly verify the coding results on one third of samples, which are randomly selected from baseline samples. After the three researchers reach a consensus on results, we compare corresponding behavioral codes with the results of experts. Finally, the comparative analysis unfolds that the kappa coefficient k reaches 0.95, indicating a high degree of inter-rater reliability on coding results (Landis & Koch, 1977). Thus, the coding rule is formulated as shown in **Table 2**.

In this way, the remaining 50% of posts will be identified with the coding rule above. Here a special situation may have occurred that a sentence could be identified by multiple behaviors. For instance, if a thread post contains an inquiry sentence, then it could be jointly annotated with LT and AQ. Therefore, a post-level behavior may contain some sentence-level behaviors. In this sense, some fine-grained engagement patterns could be detected within the textual context.

Content-level behaviors

The content within forum posts may reflect individual motivation and discourse behaviors according to the speech act theory of Austin (1975), which suggested that one person actually was conducting a certain behavioral tendency while writing words. Like the studies of Romero, López, Luna, and Ventura (2013) and Huang, Dasgupta, Ghosh, Manning, and Sanders (2014), we utilize numbers of notional words (NW) in all posts, notional words used per post (AN), sentences (ST), asking questions (AQ) and expressing opinions (EO) to respectively represent engagement indicators of each student in forums, wherein NW and AN are word-level features, ST, AQ and EO are sentence-level features. Especially, unlike the previous research, we only extract notional words referring to terms with specific notions, ideas or other actual meanings, such as a person, a thing, an act, an emotional orientation or an evaluation object, in contrast to a relational word without semantics. These words could be utilized to measure vocabulary richness of students in discussions. The three content-based variables would be measured as shown in **Table 3**.

Table 3. Coding rule of content-level behaviors

Code	Behavioral variable	Description	Example
NW	Notional words used in all posts	Indicate total number of notional words with actual meanings within all posts which a participant delivered.	E.g., a post "我认为心理学能了解别人怎么想的，所以选修了。/I think that psychology could help me know how others think, so I elect it." has 7 notional words such as "我/I", "认为/think", "心理学/psychology", "了解/know", "其他人/others", "想/think", "选修/elect".
AN	Notional words used per post	Indicate number of notional words averagely used for writing a post for a participant	
ST	Posting sentences	Indicate total number of sentences within all posts which a participant delivered. The sentences are separated by "。", "？", "！", ".", "?", "!" and "......".	E.g., a post "我们每一个视频都必须得看完吗？中途退出算不算时间呢？/Do we have to watch every video? Is it ok to exit halfway?" has two sentences, such as "我们每一个视频都必须得看完吗/Do we have to watch every video?" and "中途退出算不算时间呢/Is it ok to exit halfway?".
AQ	Asking questions	Ask a question to seek for answers. The specific indicators contain "?", "what", "why", "how", "which" or other key question symbols.	对于强迫症用厌恶疗法怎么治疗啊？/How to treat obsessive-compulsive disorder with aversion therapy?
EO	Expressing opinions	Express personal views on a learning problem in subjective ways, including "I find", "I (do not) think", "I (do not) feel", or "I (do not) think", etc. within posts.	我认为心理学中的"意识"与哲学中的"意识"是研究的方向不同而已/I think that "consciousness" between psychology and philosophy is different in terms of research direction.

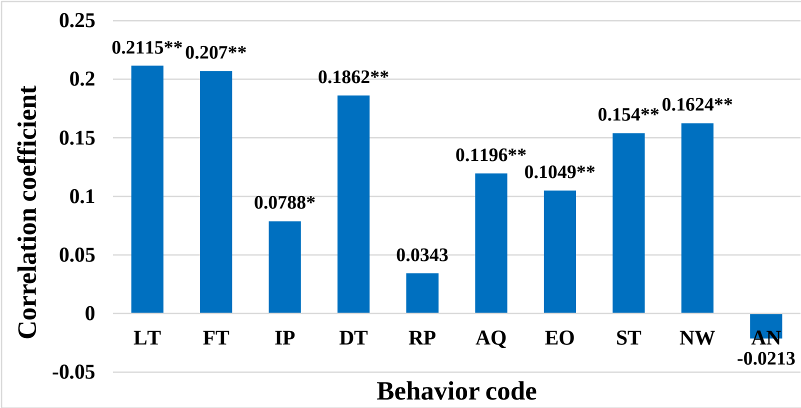
Table 4. Distribution of emotional terms in dataset

Emotion	Words in lexicon	Matched emotional terms	High-frequency emotional terms (top 10)
Positivity	9586	47782	"正式/formal", "深远/profound", "愉快/happy", "很充沛/very abundant", "聚精会神/concentrate", "钟情/love", "深信/convinced", "喜爱/like", "舒适/comfortable", "很深厚/very deep"
Negativity	12871	30924	"压制/suppress", "非议/criticism", "闭塞/closed", "不深刻/not profound", "乏味/tedious", "不赞同/do not agree", "垃圾/rubbish", "浪费/waste", "不必要/unnecessary", "不可行/not feasible"
Confusion	934	6500	"可不可以/can or not", "莫名其妙/mysterious", "迷茫/perplexed", "似是而非/paradoxical", "迷失/lost", "两难/dilemma", "缘何/why", "怪异/strange", "彷徨/hesitant", "举棋不定/indecisive"

Measure of Emotional States

In order to precisely capture emotional terms in posts, we adopt the Chinese emotion lexicon constructed in Yang, Liu, Liu, Min, and Meng (2014) to match terms indicating positive and negative moods or evaluations. Simultaneously, with suggestions of two psychology instructors on students' confused expressions, we formulate a confusion emotion word set with some Chinese terms indicating students' uncertain (e.g., "不确定/not sure", "是不是/is or not"), hesitant or sceptical (e.g., "为什么/why", "真的吗/really"), incomprehensible (e.g., "不清楚/do not know"), inquiring (e.g., "请问/excuse me", "谁知道/who know", "怎么做/how to do") and other potential confused feelings in learning. The constructed lexicon and their distributions in discussion posts are described as Table 4.

To characterize emotion states of students, the concept of emotion density (ED) is introduced to represent the strength of each type of emotion over a week. Here a week is viewed as a sampling period to obtain a more significant emotional variation. It is worth to note that, unlike the research of Wen et al. (2014) focusing the sentiment ratio (positivity/negativity) in posts, ED reflects the level of emotional strength for each of positivity, negativity and confusion during a period, hence ED would be less than or equal to 1. Therefore, ED can be used to characterize varying trend of each emotion of a student during course progress. To this end, by the NLPIR Chinese word segmentation system (Zhang, 2018), we first split the content of each post into words by order. Then, the positivity, negativity and confusion words in the emotion lexicon are respectively picked to match valid emotional terms in the word sequence. The matching is a procedure of word-by-word scanning in order, and the negative



Note: ** p<0.01, * p<0.05

Figure 1. Pearson Correlation coefficient between students' engagement behaviors and course performance

prefix before each emotional term would be captured. That is, if a negative prefix *p* like "难/difficult", "非/un", "不是/not", "不太/not too" is scanned before an emotional term *w*, the negative prefix and *w* would be combined together as (*p*+*w*) to form a new emotional term with an opposite polarity to *w*. These constructed synthetic terms would be automatically picked into the corresponding emotion set to facilitate the subsequent emotional matching.

ED is calculated to indicate the occurring strength of an emotion category *e* over time *t*. For formulating the calculation criterion, we define the following symbols:

- ED_e^t: Emotion density of emotion category $e \in \{p, n, c\}$ during *t*-th week.
- $numS(t)$: Total number of sentences within all posts during *t*-th week.
- $match(w_e^{s_i})$: Number of matched words attributing to emotion category *e* within sentence $s_i \in numS(t)$.
- $length(s_i)$: Number of words within sentence s_i.

To obtain a more consistent emotional information, we define the density of each emotion across the post set in a period based on the method of O'Connor, Balasubramanyan, Routledge, and Smith (2010). The calculation formula of ED can be described as follows:

$$ED_e^t = \begin{cases} \frac{1}{\|numS(t)\|} \sum_{s_i \in numS(t)} \frac{match(w_e^{s_i})}{length(s_i)}, length(s_i) > 0 \\ 0, length(s_i) = 0 \end{cases} \tag{1}$$

Here ED characterizes the evolutionary trends of collective emotions over course weeks by matching emotional terms on sentence level. Thus, the positive, negative and confused emotion densities (namely PED, NED and CED) can be calculated to detect the average sentiment strength of a certain group across a certain week. It is worth to note that the value of ED ranges from 0 to 1. The value of ED would equal 1 in an extreme case when all the words within s_i are emotional terms from the same emotion type. The value of ED would equal 0 when there are not any sentences or emotional terms during *t*-th week.

RESULTS

Engagement Behaviors and Course Performance

In this section, we adopt the designed coding rule to automatically annotate engagement behaviors within each post. Particularly, RP, DT, IP, FT and LT will be identified on posting-level since they are consistent with posting actions of students. As for the content within forum discussions, ST, AQ and EO will be identified on sentence-level, while AN and NW will be counted to capture the words with actual meanings.

Association between engagement behaviors and course performance

To address the first question, all the behavioral counts are viewed as independent variables, the dependent variable is course performance indexed by each student' score in the final exam. The result of correlation analysis is shown in **Figure 1**.

The result reveals the degree of association of ten behavioral variables with course performance. First, there are significant correlations between most of behaviors and final grades. The frequencies of launching and following

Table 5. t-test results on eight significant behaviors of the high- and low-performing groups

Group	Behavior code															
	LT		FT		IP		DT		AQ		EO		ST		NW	
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
High-performing	4.98	0.62	16.18	1.60	1.31	0.42	15.72	2.08	53.99	7.75	66.39	8.26	170.44	18.16	903.54	94.76
Low-performing	1.41	0.23	6.44	0.72	0.915	0.13	4.37	0.72	26.50	6.01	38.90	10.81	83.90	15.67	419.65	65.01
t-value	23.70***		25.41***		3.18		21.37***		7.14**		4.23*		12.13**		15.69***	
p-value	0.000		0.000		0.075		0.000		0.008		0.040		0.001		0.000	

***p<0.001; **p<0.01; *p<0.05

thematic posts are significantly associated with students' final scores. Second, receiving more follows means that they might establish an attractive topic engaging peers to actively discuss within a thread. Also, the popularity of threads (indicated by thread depth) tends to be correlated with the publisher's course performance. Third, for the content-level behaviors, asking questions, expressing opinions, as well as writing multiple sentences and diverse vocabulary are all significantly correlated with course performance. This seems that, discussing with rich language, seeking for helps and sharing learning feedback with peers all indicate students' knowledge construction skills to some extent.

To explore the specific behavioral characteristics of the high-performing group, we examine the differences between the high- and low-performing groups with t-test on eight significant behaviors, i.e., LT, FT, IP, DT, AQ, EO, ST and NW, which exhibit moderate correlations coefficients with course performance. The t-test results on these engagement behaviors of the high- and low-performing groups are shown in **Table 5**.

The results above show that behavioral frequencies between the high- and low-performing groups are significantly different except in IP. The high-performing group tends to be more active than low-performing group in the seven behaviors of LT, FT, DT, AQ, EO, ST and NW. Relatively, LT ($t(375)=23.70$, $p<0.001$), FT ($t(375)=25.41$, $p<0.001$) and DT ($t(375)=21.37$, $p<0.001$) and NW ($t(375)=15.69$, $p<0.001$) seem to be most statistically significant in distinguishing the high-performing and low-performing groups. The possible reason is that, compared with low-performing group, except for participating in more thematic postings, the high-performing group could offer relatively influential topics attracting more followers, and used richer notional words in discussions. In addition, both AQ and EO show significant differences at 0.05 level between the high- and low-performing groups, which implies the students in the high-performing group averagely proposed more questions and opinions than those in the low-performing group. The t-test results reveals that, the high-performing students have higher levels of engagement and influence than low-performing students in forums. However, on average, each student in both these groups only had fewer than two times of peer-interactions in writing discussion posts, suggesting these two groups seem to be similar and inactive in connecting peers during postings.

Differences between engagement behaviors of registered and non-registered students

For a restricted SPOC environment, the participation of non-registered students in discussions typically stems from the high-quality discussions and instructions in a course (Rothkrantz, 2016). Simultaneously, non-registered students need not to gain the course credits, and they engage in SPOC forums to pursue their own interests. It is worth to note that the 33 non-registered students in the *Psychology Foundation* course are completely spontaneous to engage in the course discussions. To address the second question, we conducted the difference examination between the non-registered and registered groups in terms of engagement behaviors.

As shown in **Table 6**, it could be found that the registered students performed more actively than the non-registered students only on the three behaviors of LT ($t(750)=2.15$, $p=0.043$), ST ($t(750)=4.68$, $p=0.003$) and NW ($t(750)=4.17$, $p=0.004$). But these two groups have not shown significant differences on the other five behaviors. It seems that, with an excitation of academic achievement or requirements from instructors, the registered group launched more threads as well as used richer vocabulary and sentences in posts per week. This shows a higher motivation of the registered group in launching topics and expressing discourse content. On the contrary, the non-registered group performed less actively in discussions. Seemingly, more external participants only observed the discussion processes as bystanders. Interestingly, the non-registered group received on average more follows after launching a thread. But the difference in DT was insignificant between these two groups, this is probably because there is a relatively large individual difference (S.D. = 7.95) within the non-registered group.

Table 6. t-test results on eight significant behaviors of registered students and non-registered students

Group	Behavior code															
	LT		FT		IP		DT		AQ		EO		ST		NW	
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
Registered	3.06	0.23	11.71	0.71	0.81	0.14	9.96	0.81	41.87	3.89	50.16	4.61	128.94	8.87	688.80	47.15
Non-registered	1.46	0.57	14.24	2.13	0.36	0.13	14.24	7.95	22.36	15.85	22.64	12.89	5.21	20.20	260.15	104.12
t-value	2.15*		1.93		1.83		-0.64		1.16		1.53		4.68**		4.17**	
p-value	0.043		0.067		0.721		0.528		0.257		0.140		0.003		0.004	

***p<0.001; **p<0.01; *p<0.05

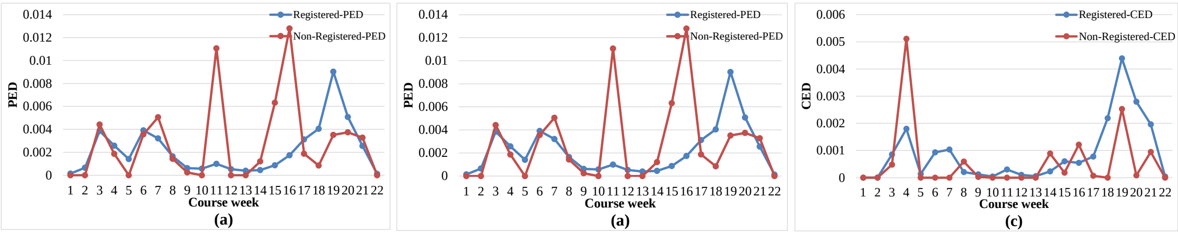


Figure 2. Average emotion densities of registered and non-registered groups across course weeks (a) PED evolutionary trends (b) NED evolutionary trends (c) CED evolutionary trends

Emotional States and Course Performance

Emotion is a critical implicit factor affecting individual learning motives in online learning processes. Compared with conventional self-report methods (Broekens & Brinkman, 2013), the textual emotion calculation could automatically detect real emotional expressions of students online without any intrusive sensory device (Rodriguez, Ortigosa, & Carro, 2013). Unlike previous related research, we incorporate confusion as a type of emotion into the comparative study to perform a comprehensive emotion analysis combining positivity, negativity and confusion, which aims to investigate the relationship between academic emotions in forums and course performance. It is worth to note that, for each emotion, we sum up an overall evolutionary trend between the two semesters of *Psychology Foundation* course by averaging two sequences of emotion densities over weeks.

Differences between emotional states of registered and non-registered students

To address the third question, we respectively calculate PED, NED and CED for the registered and non-registered groups across each week in a semester. The evolutionary trends of them are shown in **Figure 2**. For the registered group, PED, NED and CED show a similar evolutionary trend: there are two peaks during the first 7 weeks, they displayed a relatively plain trend during the middle term stage (8th to 9th week), and there is a peak in the 19th week at the end of the semester. Especially, for the registered group, each type of emotion typically had a sharp increase and achieved the highest level when approaching the end of the semester. In contrast, the non-registered group shows larger fluctuations on PED, NED and CED across the semester. Interestingly, the students from the registered group tended to have a higher CED than non-registered group at last 6 weeks of the semester (17th to 22nd week), suggesting that the registered students expressed a higher level of confusion in the last few weeks of forum interactions.

Table 7 shows the paired sample t-tests of emotional states between registered and non-registered groups, which indicates that there are not significant differences on PED, NED and CED between these two groups in total. This indicates that, whether students were registered for the course had not a significant impact on their emotional expressions in course forums. In order to explore emotional differences within each group, we conducted the paired sample t-test for each emotion density between these two groups over these 22 courses weeks, as shown in **Table 8**. This seems that, within the registered group, there is a significant difference among PED, NED and CED, and the contrast relationship is that "PED>NED>CED". Within the non-registered group, PED still represented the dominant emotion state, which is significantly higher that both of NED and CED, but there is not a significant difference between NED and CED.

Table 7. Indicators of emotion states between registered and non-registered groups

Group	Emotion State					
	PED		NED		CED	
	Mean	S.D.	Mean	S.D.	Mean	S.D.
Registered	0.0022	$<10^{-5}$	0.0013	$<10^{-5}$	0.0009	$<10^{-5}$
Non-registered	0.0028	$<10^{-4}$	0.0011	$<10^{-5}$	0.0006	$<10^{-5}$
t-value	-0.78		0.50		1.26	
p-value	0.22		0.31		0.11	

Table 8. Indicators of emotion states within registered and non-registered groups

Group	Emotion State						F	Post-hoc Test
	PED		NED		CED			
	Mean	S.D.	Mean	S.D.	Mean	S.D.		
Registered	0.0022	$<10^{-5}$	0.0013	$<10^{-5}$	0.0009	$<10^{-5}$	3.8478*	PED>NED*** PED>CED*** NED>CED***
Non-registered	0.0028	$<10^{-4}$	0.0011	$<10^{-5}$	0.0006	$<10^{-5}$	5.2954**	PED>NED* PED>CED**

***p<0.001; **p<0.01; *p<0.05

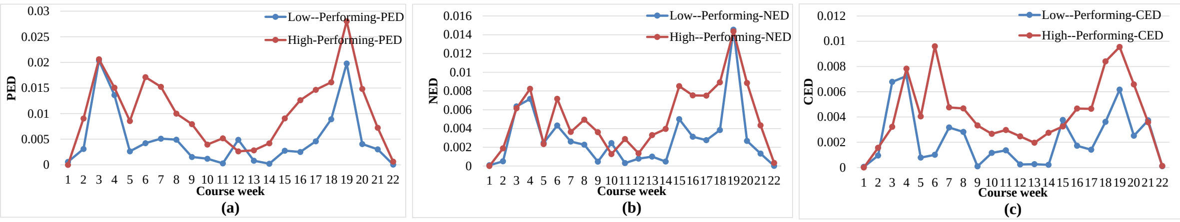


Figure 3. Average emotion densities of high- and low-performing groups across course weeks (a) PED evolutionary trends (b) NED evolutionary trends (c) CED evolutionary trends

Differences in emotional states of different performing students

To address the fourth question, we characterize the evolutionary trends of PED, NED and CED for the high- and low-performing groups over 22 course weeks, as shown in **Figure 3**. It can be observed that, the three types of emotions all show relatively high levels both at the beginning (1st-8th week) and the end (15st-22th week) phases of a semester, but show relatively low levels in the middle (9th-14th week) of a semester. In general, the high-performing group shows the highest emotional strength on PED, and achieves a peak level of PED at 19th week. In contrast, the low-performing group seems to have lower levels in all emotion densities. Especially, the high-performing group had a higher CED than the low-performing group over most time. The CED of low-performing students seem unstable during the whole semester, in which there are sharp increases at 3rd, 7th, 15th, 19th and 21st weeks. Specifically, the analyses on emotional differences are conducted within inter- and intra-group, respectively.

The emotional differences between different performing groups are shown in **Table 9**, there is a significant difference on each type of emotion density between high-performing group and low-performing group. The high-performing group tends to have higher emotional strengths than low-performing group on PED, NED and CED, among which PED can significantly distinguish from these two groups. These results reveal that the course performance is basically consistent with emotional strengths for these registered participants, and the high-performing students typically appear to have higher emotional arousals on PED, NED and CED. Moreover, an interesting phenomenon is that the high-performing group has a higher confusion than low-performing group. The possible reason is that the high-performing students tend to think about questions and express their confusion on course content to seek for help. This result is consistent with the comparative result on AQ between the high- and low-performing groups, suggesting that the high-performing group tends to be more active than the low-performing group in asking questions.

Table 9. Differences between high- and low-performing groups on each type of emotion density

Group	Emotion State					
	PED		NED		CED	
	Mean	S.D.	Mean	S.D.	Mean	S.D.
High-performing	0.0099	$<10^{-4}$	0.0047	$<10^{-4}$	0.0038	$<10^{-5}$
Low-performing	0.0050	$<10^{-4}$	0.0029	$<10^{-4}$	0.0022	$<10^{-5}$
t-value	5.6237***		4.3424***		3.3884**	
p-value	$<10^{-6}$		$<10^{-5}$		0.0028	

***p<0.001; **p<0.01; *p<0.05

Table 10. Distribution of three types of emotion densities and their difference on each performing group

Group	Emotional state						F	Post-hoc Test
	PED		NED		CED			
	Mean	S.D.	Mean	S.D.	Mean	S.D.		
High-performing	0.0102	$<10^{-4}$	0.0050	$<10^{-4}$	0.0042	$<10^{-5}$	10.2871***	PED>NED*** PED>CED*** NED>CED*
Low-performing	0.0050	$<10^{-4}$	0.0029	$<10^{-4}$	0.0022	$<10^{-5}$	2.7064	PED>NED** PED>CED**

***p<0.001; **p<0.01; *p<0.05

To examine emotional difference within each performing group, we first carry out an ANOVA analysis on three types of emotion densities for each performing group. As shown from **Table 10**, there is a significant difference among three types of emotion densities within the high-performing group ($F(2, 717)=10.2871$, $p<0.001$), while the difference among PED, NED and CED is insignificant within the low-performing group ($F(2, 717)=2.7064$, $p>0.05$). Through comparing the distributions of emotion densities of the two groups, we can find the students from the low-performing group tend to have less emotional expressions than those from the high-performing group. This may be related with the fact that low-performing students rarely engage in interactions involving opinion expressions, which results in a low level on each emotion.

In the post-hoc tests within each group, we find that the differences between PED, NED and CED within the high-performing group are more significant than those within low-performing group. For the high-performing group, the students tend to express more positive emotion in comparison to negative ($t(375)=5.5805$, $p<10^{-4}$) and confused emotions ($t(375)=5.6310$, $p<10^{-4}$). Relatively, for this group, the confused emotion shows the lowest level compared with the positive and negative emotions. For the low-performing group, positive emotional expressions significantly outperform negative emotional expressions, while the difference between negative and confused emotions is statistically insignificant. Actually, they often had both confused questions and negative feedbacks towards learning content at the same time. For instance, the post "我承认心理学与神经系统等生物学基础有着密不可分的联系，但为什么第二章只谈神经系统而不说心理以及它们的联系，让人感觉晦涩难懂，产生了认知上的分离/I admit that psychology is inextricably linked with nervous system and other biological basis, but why does the second chapter only focus on nervous system without psychology and the relationship of them, which makes me feel obscure, incomprehensible and have cognitive separation" written by a student in low-performing group implies that the knowledge about nervous system taught in *Psychology Foundation* course was both confusing and complex for this learner (both "why" and "obscure" indicate the confused emotion, "incomprehensible" indicates the negative emotion). Hence, the simultaneous appearance of the two types of emotions in a sentence may result in a small difference between them.

DISCUSSIONS AND CONCLUSIONS

In this study, we adopt the behavior analysis and emotion density calculation to jointly explore engagement patterns of students in SPOC forums across 22 weeks of observation. We examine whether students' engagement behaviors and emotional states are different in terms of their course performance or not. Thus, four research questions are addressed as follows.

Regarding the first question, we automatically extracted ten engagement behavioral features for each participant, in which launching threads, following threads, average depth of contributed threads are the three features most significantly associated with course performance. And the high-performing group was more active than low-performing group in discussions except for the interactive posting. Among these engagement behaviors, the deeper knowledge construction behaviors implied by interactive postings, asking questions and expressing opinions are lowly associated with course performance although the high-performing group performed more actively in these behaviors. This suggests that the behaviors associated with learning performance are mostly reflected in the quantity of interactions rather than the quality of engagement. Correspondingly, Shaw and Kathleen (2017) have shown that there was no significant relationship between forum quality and posting/replying behaviors, and these behaviors could not effectively explain forum quality, which is indicated by depth of discussion and critical thinking. Therefore, it is possible that the students were not prepared for higher quality discussions and there was a lack in effective guidance and stimulations of high-order thinking. The latter could potentially be supported via activities such as problems' creations and solutions (Tofade, Elsner, & Haines, 2013), situation-related topic discussions (Wang, Wen, & Rosé, 2016), feedback exchange among teachers and students (Ertmer et al., 2007), or assessment of discussion contributions (Klisc, McGill, & Hobbs, 2017), etc.

Regarding the second question, we conduct a comparative study between the registered group and the non-registered group. The registered group was more active than the non-registered group in launching thematic posts. This result is consistent with the conclusion involving MOOC learners derived by Khalil, Kastl, and Ebner (2016), indicating that the voluntary external participants generally had a low posting frequency and certification rate compared with registered group. This phenomenon seems that a strong motivation to achieve good course performance had a positive effect on posting thematic content in forums. However, the registered students tend to be similar to the non-registered students in activity levels of most engagement behaviors. It seems that the course credit is not a major driving factor for students to engage in various activities (interacting with peers, questioning and expressing opinions) in forums. This result is opposite to that reported by Kursun (2016), which shows the credit bearing group had a significantly higher extrinsic goal orientation than non-credit-bearing group in engagement in MOOCs. This also implies that, the interactivity and incentives of course forums still need to be improved and diversified. If reasonably designed, SPOCs would attract different types of students (internal or external students) to equally engage in interactions in course forums.

Regarding the third question, we characterize the temporal emotional states and their differences between the registered- and non-registered students. Compared with the non-registered group, the registered group had a more and consistent evolutionary trend in PED, NED and CED across the whole semester. When it come to the end of the semester, all emotion densities tend to sharply increase, suggesting that the registered students had a higher emotional arousal in preparing exams. Especially for the confused emotion at the end of the semester, the registered group had a higher emotion density than the non-registered group. This phenomenon seems to be related to the learning objectives or motivation of students. For registered students, they faced the pressure of exams which are for obtaining an enough credit, while non-registered students did not need to face. Therefore, a registered student who needed to prepare for exams might have more confusion and thus they needed to request helps of peers, and the confused emotion typically occurred at the end of the semester. Interestingly, this is similar to the finding in Yang et al. (2015) which indicates that students' confusion was closely related to behavioral patterns in preparing online quizzes and exams. This seems that the exam might be a potential incentive to registered students' confusion. However, there are not significant differences between emotional states of these two groups in total. Only within each group, there is a significant emotional difference among PED, NED and CED, in which the positive emotion accounts for dominant proportion of all emotional states, suggesting an optimistic academic emotion among the entire population.

Regarding the fourth question, we detect the temporal emotional states of the high- and low-performing students. For both high- and low-performing groups, the temporal emotional states of PED, NED and CED all show a common trend: the high emotion densities have sharp increase at the beginning of the semester, then decrease at the middle of the semester, and finally have a sharp increase when approaching the end of the semester. This seems that the discussions at the starting and end stages both had incentive effects on emotional expressions. Compared with the low-performing group, the high-performing group had higher emotion densities over a semester. This indicates that the calculation of emotion densities might contribute to identify the potential at-risk students (average PED$\leq$0.0050, NED$\leq$0.0029; CED$\leq$0.0022), which would be beneficial to improve the overall learning performance and success rate in SPOCs. Unlike our study, in the study of Ramesh et al. (2013), negative emotions did not show a significant discriminability on students' engagement/performance, which was considered to be related to the context in which the emotion was expressed. Therefore, the specific context (discussed topic, activity type, course content, etc.) in which each type of emotion was expressed might mediate the emotional difference between high- and low-engaging groups, and should be incorporated into the analysis of forum engagement in future work. As for the within-group emotion states, the high-performing group exhibits an emotional engagement pattern of "PED>NED>CED", i.e., the positivity and confusion were the most and least expressed emotions of this group, respectively. Nevertheless, within the low-performing group, there is a similar emotion density between negativity and confusion, which may result from the simultaneous expressions of these two types of emotions in a sentence. Interestingly, it can be revealed that the high-performing group seems to express more negative and confused learning feedback than the low-performing group, which is inconsistent with their performance. It remains inconclusive. One possible reason is that the high-performing individuals might more effectively solve the confused or difficult questions to digest some obscure knowledge, and thus succeed in final examination. Another reason may be that low-performing individuals were less involved in emotional interactions or exchange of feedback, thence their real confusion was rarely exposed into interactions, which is closely related with their low engagement in the forum discussions.

Thus, reports on engagement patterns could be valuable to establish a participatory SPOC learning environment for STEM students if they enable instructors to understand how students interact in forums, especially for those who lowly engaged in discussions as well as expressed negative or confused emotions. Based on these findings, instructors could adjust interactive teaching strategies and focus on the at-risk individuals with low emotion densities at a suitable time. Hence, these results may have critical implications for formulating targeted interventions to improve learning experiences and performance of students in technology-enabled formal learning environments (Arnold & Pistilli, 2012; Wise, 2014).

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An Automatic UI Interaction Script Generator for Android Applications Using Activity Call Graph Analysis

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ABSTRACT

As the Android's growth in global market share, the security problem of Android OS becomes more and more serious. According to statistics, there are 84% of smartphone users use Android OS. The popularity brings not only wealth into Android market but also more and more malicious applications. Malicious developers want to steal private information such as credit card number, contacts, or email from Android phones. Android has sustained security issue for a long time. Academics also have put many efforts to solve the problem. Dynamic analysis is one of the methodologies for Android malware detection. Current execution of dynamic analysis needs to deploy heavy human resources. There is always someone needed to access the user interface manually, or the work can hardly be finished. In this work, we propose an approach on Android UI automation. Our implemented system output an Android monkeyrunner scripts, which is custom made for input Apk. The script program can trigger UI event automatically and deal with exception conditions while executed in monkeyrunner.

Keywords: Android, malware detection, automation, activity call graph

INTRODUCTION

Smartphones popularity is growing rapidly over these years. Many people cannot live without a smartphone these days. Because they do all kind of things with their phone, including to read, entertain, socialize and work. A report from International Data Corporation (IDC) shows there is 85 percent global smartphone market share for Android OS till the first quarter of 2017 (Smartphone OS market share, 2017). And there are over 3.5 million applications on Google Play market since December 2017 (Google Play: number of available apps 2009-2017, 2017). These numbers indicate the leading position of Android and an enormous benefit that one can get by successfully spreading malicious apps on the platform.

Android has become a major target for malicious developers because it is widely used. Unfortunately, the openness of market even intensifies the problem. Security issue of Android applications has been criticized for a long time. Android developers can upload applications to market with a few screening process. Besides Google Play, there are still some third-party markets, such as Amazon and Samsung which provide their platform for the user to upload and download Android apps freely.

Motivation

Dynamic analysis on Android application getting more important since dynamic loading technique appears. Yet it is a resource-consuming process without automatic device access. During the inspection, there should be a human operator taking care of the process. Additionally, Android developer creates apps with a stunning speed.

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Contribution of this paper to the literature

- An approach can go through every version of Android OS and different environments.
- A system is build up specifically in the light of each input Apk analysis result.
- This collaborative model can extract information from Apk files and generate automatic UI scripts for the well-known tool "Monkeyrunner" to perform dynamic analysis in an automated manner.

Without automation, dynamic analysis can never catch up the upload rate of apps. That means screening process of new apps will eventually fail. Google deploys Bouncer (Hou, 2012) on Play market somehow supports our argument. The Bouncer basically is an automatic dynamic analysis tool. They do not want people involved in this vetting work. Although some malicious apps can still bypass Google Bouncer. We can still catch the concept and working on it in academics.

Someone uses Monkey, a semi-random UI event tool, to fulfill the job. We can question the result of taking a random UI event trigger. Because the control flow of an application can be very complex. Monkey may miss some corner of the whole picture.

In this work, we implement a system that provides an UI automation mechanism for Android applications. The system deploys Activity Call Graph analysis that ensures we reach every part of the application. Considering that exceptions may happen while executing. Our system provides alter steps for dealing with the unexpected situation.

Organization. In Section 2, we will get an overview of Android security related topic. Section 3 describes the concept of our proposing framework. Section 4 shows our implementation detail and result. At the last, we summarize this work in Section 6.

BACKGROUND AND RELATED WORKS

Android Security

Android is a Linux-based opensource operating system released by Google. Although most of the codes of Android are implemented in Java, they transform into Dalvik executable code and executes on Dalvik virtual machine (Android – Wikipedia, n.d.). The overall framework of Android is shown in **Figure 1** (Smieh, 2012). Google's policy on the openness of Android provides not only IDE tools and SDK but also the source code of Android operating system, giving developers least constraint playing in the ground. Google has successfully gathered a developer community that has never been seen. Yet they open the security net and cannot guarantee safety in the field.

Because of the popularity of Android phones, there are always malicious developers who exploit apps to steal users personal information. Credit card and contact book are major targets. Once a malicious app steals this information, they send back the data through SMS or internet. The competition between malicious apps and Android security system has been going for a long time. Android security system deploys permission analysis to break the exploit of message sending while the attacker then brings code transformation to avoid the detection. Many researches devote their contribution to Android security (Baskaran & Ralescu, 2016), yet the battle is still severe.

A lot of malware detection technique and tools has been proposed to counter this rapidly growing malicious application. But due to malicious application keep evolving, some of those technique such as traditional signature-based detection system become deprecated. There is an increasing need for alternative malware detection system to complement and rectify those traditional signature-based system. Because of the reason above, Android UI-based detection system starting to gain some popularity since it can detect the code-transforming malware with advance dynamic loading that is otherwise would be imposible for static detection such as signature-based detection to detect.

Android App Structure

Apk is an Android application archive file consisting folders and files as shown in **Figure 2** (Faruki et al., 2014). AndroidManifest.xml stores the meta-data including package name, permissions used, definitions of Activities(screen controller object), Services, Broadcast Receivers or Content Providers, supported version and libraries used. There are files of screen layout, images, icons, animations stored in the path /res/. Assets folder contains resources without compile. The execution code is compiled into Dalvik bytecode and stored in .dex files. META-INF have the signature of the app which is the third party developer identity.

There are several tools available for disassembling Apk files online such as Apktool (Apktool, 2017) and Androguard (Androguard, n.d.). So, everyone can easily unpack an Apk file and retrieve data from it. It is convenient for people to employ those tools to help them doing research. But it can also be exploited by anyone with simple unknown code insertion and repackage the archive back.

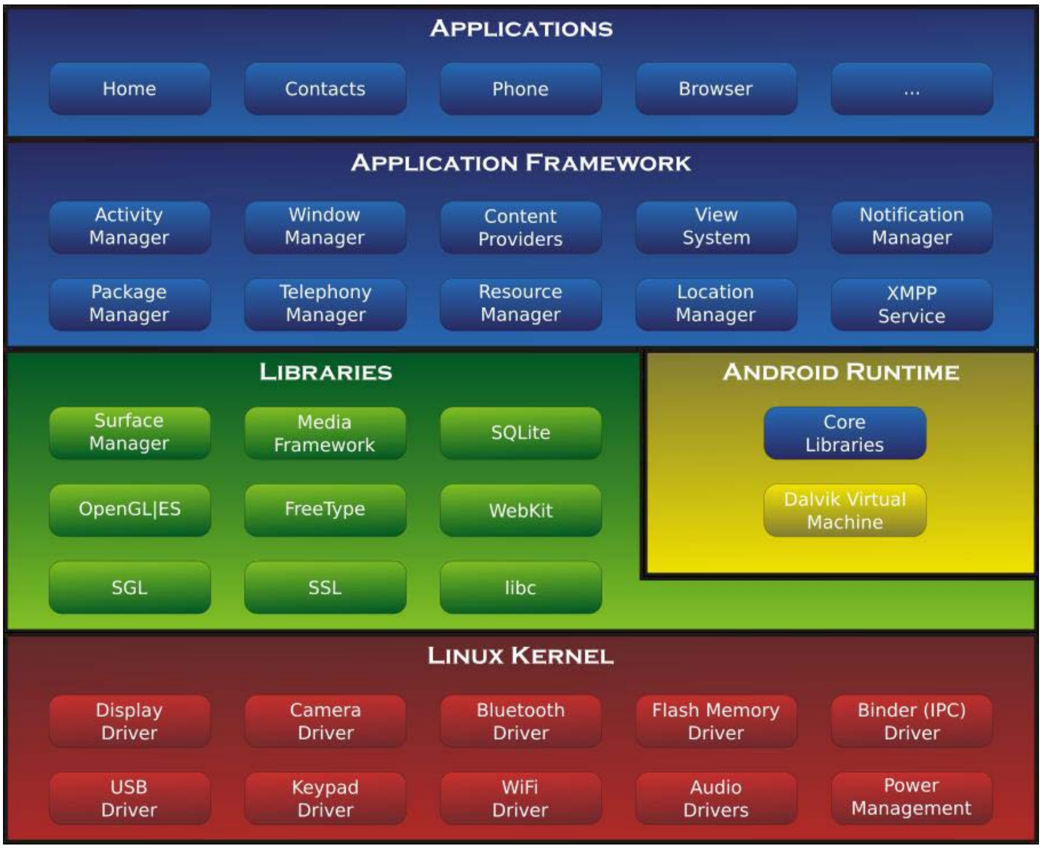

Figure 1. Android OS architecture

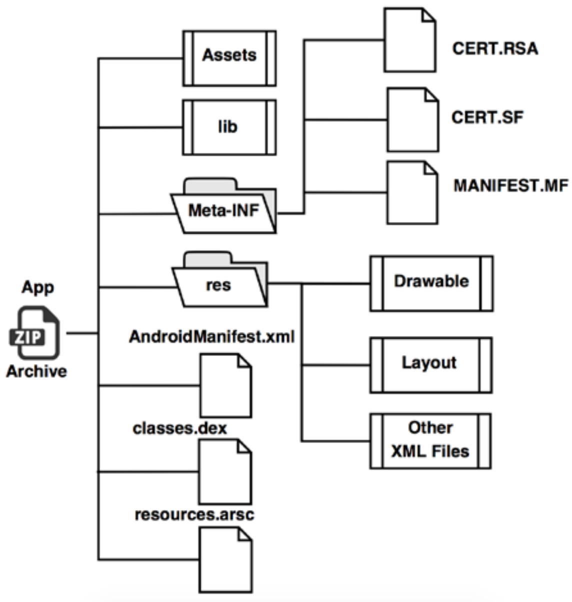

Figure 2. Android package (Apk) structure

Static Analysis

To detect malware from Android applications, static analysis is one basic way to get started. Static analysis means to inspect Android applications without executing it. One may disassemble and decompile the Apk file. Then look into permissions and other meta-data to find out if it is malicious. For more complex mechanism, there are approaches that extract signatures the compare the difference between benign and malicious apps.

Using graph analysis in static analysis is getting more interest in academics recently. In general, when it comes to take graph analysis in software, we make function as nodes, function call relationship as edges. Then we build up a function call graph. MIGDroid (Hu et al., 2014) is a system that can tell if an Apk is repackaged by analyzing its method invocation graph. They use the property of insertion code are usually apart from original code part. There is little interaction between these two division so MIGDroid makes decision under the standard.

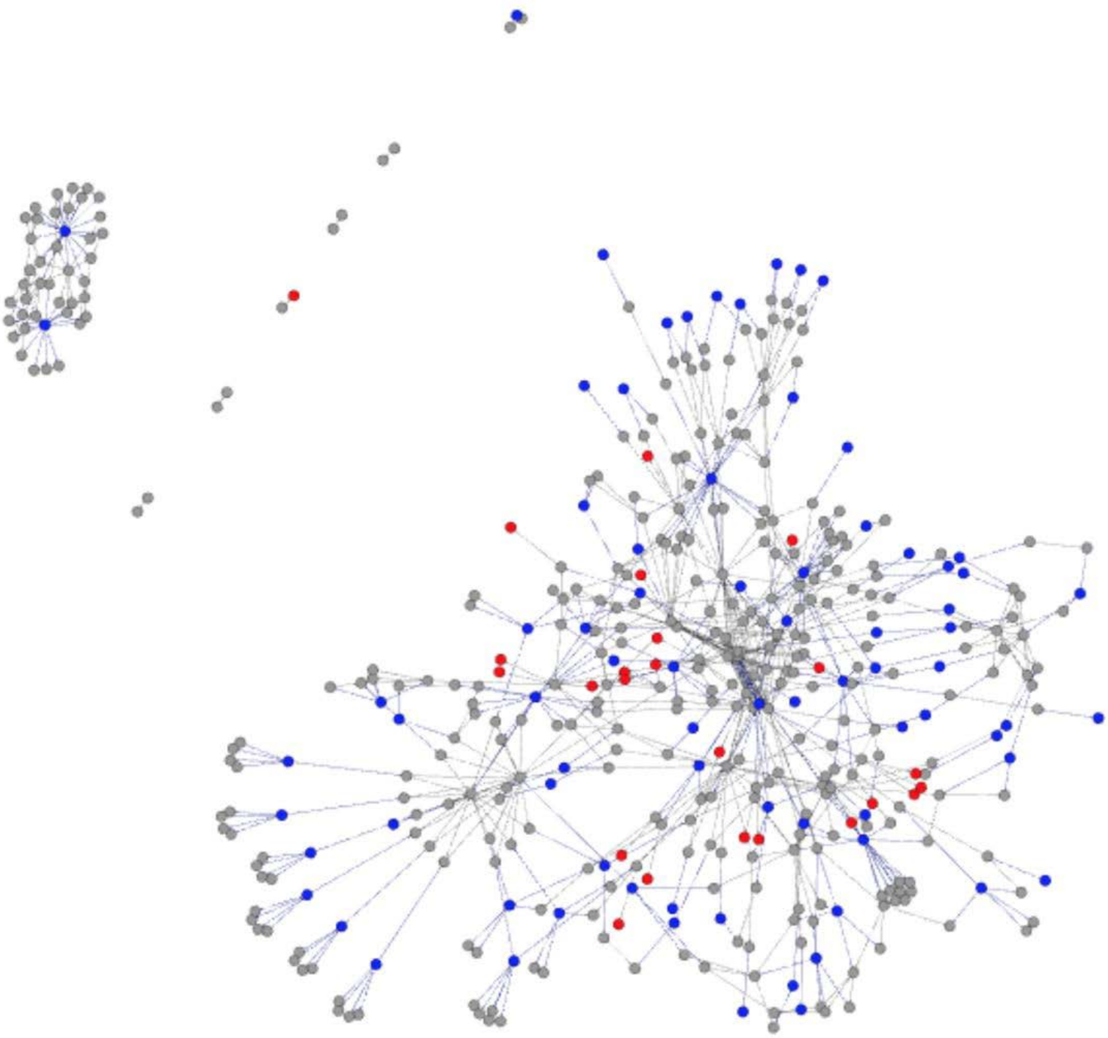

Figure 3. MIGDroid analysis Apk by method invocation graphs

Static analysis can perform a fast malicious detecting since there is no need to execute the program, but it would suffer from code transformation. It is found out vulnerable to advanced dynamic payload techniques. Researcher, lately, tend to deploy dynamic approach or hybrid approach for Android malicious app detection.

Dynamic Analysis

As long as mobile malware detecting technique improves, Android malware becomes more complex and use advanced dynamic loading to evade static detection such as Java reflection or native code execution. There will be necessary employing dynamic analysis to detect those evasion tricks. Research indicates that a lot portion (32.8%)

of apps downloaded from Google Play include dynamic loading behavior (Zheng, Sun, & Lui, 2014). Dynamic loading means a program can load libraries into memory at runtime, and jump to that address to execute functions in the dynamic libraries. In an explicit way, we can call it transformation of the program. It does not mean that every application with dynamic loading is malicious, but there surely some code we cannot retrieve under static analysis mechanism. Actually, dynamic payloads have become a tool that is used to hide malicious code in Android apps. As a result, inspecting the app while in execution is necessary to find out malicious behavior.

DroidTrace (Zheng et al., 2014) utilizes both static and dynamic analysis approach in its detection. The system made an improvement in detecting code transforming. Furthermore, they use a method called "forward execution" which physically modifies an Apk dex code to make the detection process can be done without manually access. It is noticeable they deploy their own automation mechanism into dynamic analysis, because not many researches work on this issue.

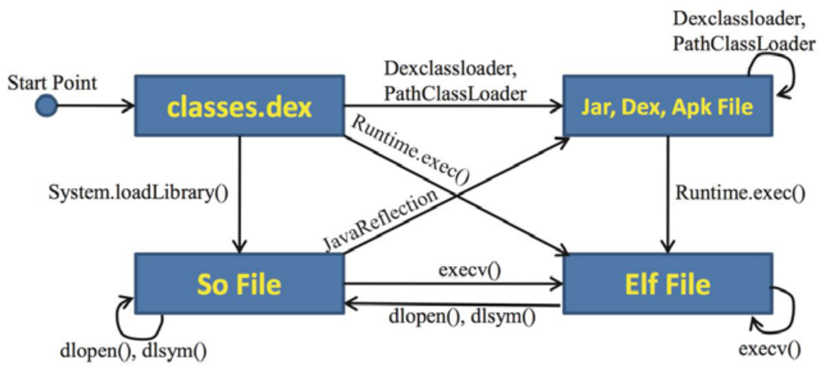

Figure 4. Relationships between dynamic payloads components

Dynamic Analysis Automation

Android applications are UI-based program. Traditionally, there would be manual effort while doing dynamic analysis. Therefore increases a huge amount of cost in the process. To avoid such cost, one may want to deploy automatic technique so that it is possible to verify apps by batches without heavy human efforts. On the other hand, as what we mentioned before, the total amount of apps growth rapidly in Android markets. There is not enough time and resources for a company to manually inspect every new uploaded application. Google has already deployed an automatic dynamic inspector called Bouncer for their Play market. It is necessary to build up automatic process for every dynamic analysis approach.

One of the most popular Android UI automation tools is called *Monkey* (Android monkey, n.d.). Monkey is a built-in tool in Android Debug Bridge (adb) which is provided within Android SDK. Originally, Monkey is made for Android developers to do load testing. It can generate semi-random stream of UI trigger events on Android apps so one can test their own app without human intervention. The benefit of deploying Monkey as automatic tool for dynamic analysis is that it comes along with Android SDK. Users do not have to install other program or environment and it can be called by using adb shell script which is easy to use. There are some concerns while using Monkey to automate dynamic analysis. Because it takes a semi-random stream to trigger UI events, it cannot guarantee ongoing analysis to reach every *Activity* (object type which hold a screen.) Or there can be redundant events which are the same be triggered several times that lower the efficiency of the process. Monkey does not know if the analysis is finished or not. User should set a duration or event trigger count before start using Monkey.

In Section 2.4, we find DroidTrace implement its own UI automation. To establish UI automation, DroidTrace employs repackaging technique to get a modified Apk for inspection. They insert UI trigger code after every UI object is declared. In this way, UI event will be triggered without manual access. Though we can see that it shows it's success in detecting dynamic loading, their automation is too sophisticated. Moreover, the modification will interfere if the UI calling structure was too complicated.

SmartDroid (Zheng et al., 2012) conducts the research that pursuits UI automation as well. However, it takes a lot more effort than DroidTrace. They modify one Android emulator so they can catch API calls inside the framework, also to ensure the application can only step in their designed path. SmartDroid's UI automation approach is wonderful, yet it will suffer from repeatedly modification while emulator updated.

Automated Dynamic Analysis Integrity

In most cases, dynamic analysis will deploy an emulator. Analysts run Android OS and the apps which will be analyzed on this emulator. Then they set up an out-side monitor recording APIs the app has used. That data will be collected and transferred into some factors to help decision making. Under this process, one can figure out the coverage of Android app process path reached during the analysis is critical for data collection and final decision making. Malware, for example, in some cases are repackage apps. Some malicious developers make their malware from repackaged normal apks meanwhile inserting malicious code into it (Hu et al., 2014). Those apps, in this way, will spread faster by taking the fame of original app. Real world example such as malicious Instagram (Zhang, Niu, Wu, Wang, & Xue, 2013) has reached over 30 million people. In this case, there is only few code part involves malicious behavior. Consequently, we need more precise and complete UI trigger to extract its behavior.

SYSTEM DESIGN

To fulfill the task of automatic accessing UI element on Android platform, we choose to generate scripts that can be run on existing Android debug tool. Using such existing tool, our approach can be performed across every version of Android OS and different environments.

Our proposed system, AndroAutoScript, extracts information from Apk files and generates automatic UI script of monkeyrunner to help dynamic analysis automation. Monkeyrunner is a tool coming with Android SDK which provides a programmable interface to run custom scripts that operate with Android applications (Android monkeyrunner, n.d.). We can write a Python program as input to describe a function sequence that operates Android device. Functions such as Install package, touch certain UI component, take screenshots are included. As monkeyrunner possesses a well-defined toolset, we can realize our purpose by using it. The overall framework of AndroAutoScript is shown in **Figure 5**. This framework includes a script generator on the left which deploys Apk analysis methods to build up an UI automation script according to the program structure of input application. In the center is our main output, the UI automation script, which possesses three major functions that is specifically designed for this work. As we familiar with, the script will be the input of a script runner that performs as automatic UI event triggering in a dynamic analysis environment. In following sections, we will go through the idea of our system design.

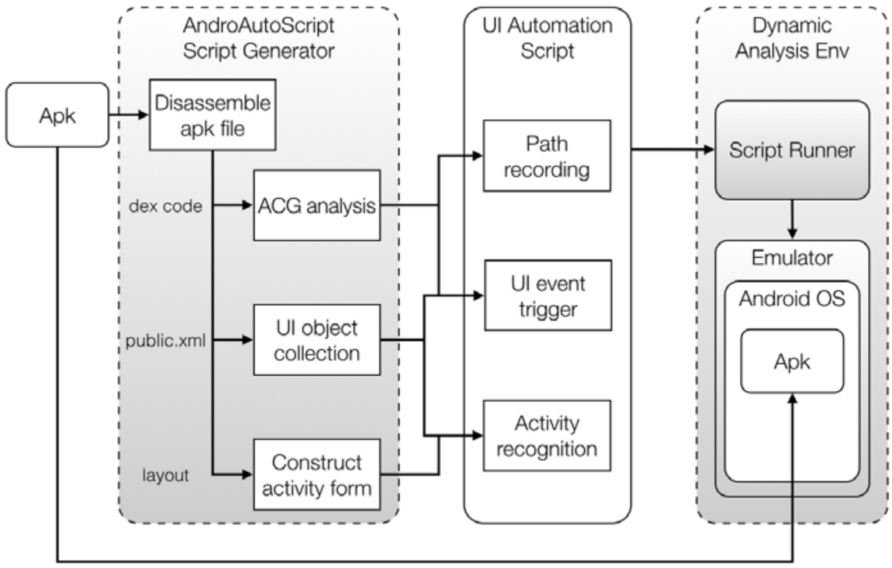

Figure 5. Framework of AndroAutoScript

Script Generator

Apk disassembling

To build up an UI interaction script that can precisely trigger UI components in desired order, we have to, firstly, extract information from target Apk file. By disassembling Apk, we can obtain all information about the

Android application. Smali code contains the program structure. For readable reason, we further decompile smali code into Java. Then we can extract information by using Java parser.

One important information we can learn from disassembled code is the Activity calling structure. An Activity instance, in Android framework, controls a whole hierarchical content within a showing screen. In other words, all UI objects are controlled by Activity class instances. As Android applications and OS itself are UI-based program, Activity Call Graph (ACG) plays no less role than Function Call Graph (FCG) in program control flow analysis. In Android framework, calling of next Activity is completed through Android API. There is function call like *startActivity* or *startActivityForResult* can help the process. In this stage, we further collect the information of UI objects and Activity content by disassembled XML files.

```
Lbedminton/edu/nthu/CompareVideoActivity$1; onClick (Landroid/view/View;)V
    public void onClick(android.view.View p5)
    {
        v1 = new android.content.Intent();
        v1.setClass(this.this$0, bedminton.edu.nthu.CompareListActivity);
        v0 = new android.os.Bundle();
        v0.putString("acquire_up", );
        v1.putExtras(v0);
        this.this$0.startActivityForResult(v1, 0);
        return;
    }
```

Figure 6. Example code - onClick method

Activity call graph analysis

In this phase, we parse the decompiled code and extract the Activity call relationship then we build an Activity Call Graph. ACG provides a structured data that is used to traverse paths and record visited components while running the automatic script. Android OS employ the Intent object to help Activity switches. There is an example code which is shown in **Figure 6**. An Intent instance declares the recipient and transfers data, if needed, and be used as a message for a new started component. When an application is going to start a new Activity, it will create an Intent then invoke *startActivity* or *startActivityForResult* method. Most of the Activity switch are bound with UI event listeners. Common application usages like use a tab to switch between different screen holder, or tap a button to go to next page. To construct the ACG, we can focus on these certain code parts. Then we can record both the calling relationship and UI object at this stage.

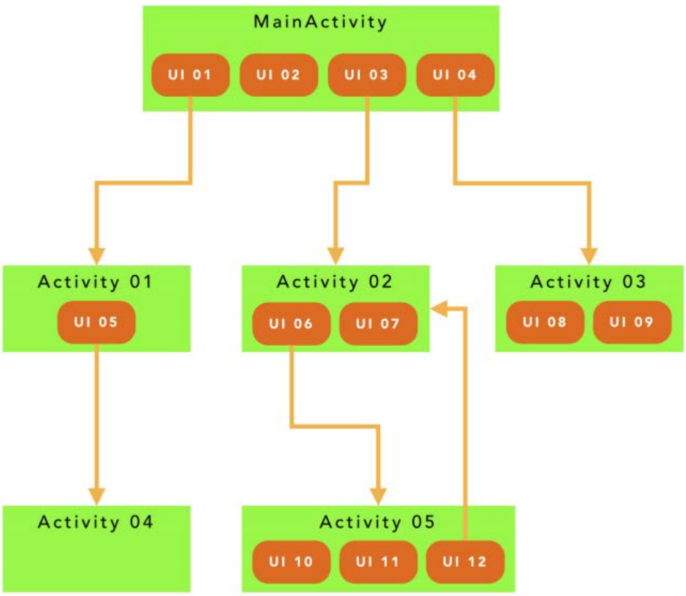

Figure 7. Activity call graph diagram

UI object list

After disassembling, we can obtain additional data sources which are the inner data of the application. Android application uses XML files as storage or register data to help the data access, such as AndroidManifest, Activity layout, and UI strings. These files are archived and encoded within an Apk file. If we use apktool (Apktool, 2017), an open disassembling tool for Apk file, to decode an Apk, there would be a XML file named "public.xml" under the path "/res/values/". Under /res/, an Apk keeps its resource data files. The file is used to store UI objects' type, id, and name mapping. Some of these saved objects are interact-able, others are not. We can find those interaction UI object by matching public.xml with the decompiled code of the application. While, in an Android application, programmers set up a UI interaction component, they call "set some interaction listener" method such as *buttonA.onClickListener*. Following the clued, we can trace back that *buttonA* has been set up an id before. That id will be found corresponding to public.xml and it is how this job be done. In this function, we collect all UI Objects those are matched by above approach and record their higher level class to pass to script as reference.

Table 1. Example of public.xml content

<public type="id" name="button_cp_up_play" id="0x7f050000" />
<public type="id" name="button_cp_up_pause" id="0x7f050001" />
<public type="id" name="button_cp_up_stop" id="0x7f050002" />
<public type="id" name="button_cp_up_choose" id="0x7f050003" />
<public type="id" name="surfaceView_cp_up_demo" id="0x7f050004" />
<public type="id" name="surfaceView_cp_down_student" id="0x7f050005" />
<public type="id" name="button_cp_down_play" id="0x7f050006" />
<public type="id" name="button_cp_down_pause" id="0x7f050007" />
<public type="id" name="button_cp_down_stop" id="0x7f050008" />
<public type="id" name="button_cp_down_choose" id="0x7f050009" />
<public type="id" name="imageView1" id="0x7f05000a" />
<public type="id" name="textView1" id="0x7f05000b" />
<public type="id" name="ButtonActiveDemo" id="0x7f05000c" />
<public type="id" name="ButtonActiveRecord" id="0x7f05000d" />
<public type="id" name="ButtonActivePlay" id="0x7f05000e" />
<public type="id" name="ButtonActiveCompare" id="0x7f05000f" />

```
Lbedminton/edu/nthu/MenuActivity; onCreate (Landroid/os/Bundle;)V
    public void onCreate(android.os.Bundle p3)
    {
        super.onCreate(p3);
        this.setContentView("0x7f030001");
        this.setRequestedOrientation(1);
        this.ButtonActiveDemo = this.findViewById("0x7f05000c");
        this.ButtonActivePlay = this.findViewById("0x7f05000e");
        this.ButtonActiveRecord = this.findViewById("0x7f05000d");
        this.ButtonActiveCompare = this.findViewById("0x7f05000f");
        this.ButtonActiveDemo.setOnClickListener(new bedminton.edu.nthu.MenuActivity$1(this));
        this.ButtonActivePlay.setOnClickListener(new bedminton.edu.nthu.MenuActivity$2(this));
        this.ButtonActiveRecord.setOnClickListener(new bedminton.edu.nthu.MenuActivity$3(this));
        this.ButtonActiveCompare.setOnClickListener(new bedminton.edu.nthu.MenuActivity$4(this));
        return;
    }
```

Figure 8. Example code - UI listener set up

Activity form construction

Besides public.xml, our approach utilizes other resource data under /res/. We can find layout files of each screen holder, or *Activity* instance, under /res/layout/. A layout file describes how each *Activity* deploys and displays elements on mobile screen. There are several *Activity* class, generally, in an Android application to control different screen. According to these layout files, we can mark up calling edges of ACG which represent *Activity* call trigger as well as an UI interaction object. These data provide more complete information of one *Activity* node on ACG.

Another reason we retrieve layout files is to provide our script the ability to recognize current screen. In this stage, we divide UI object collection we obtain before into different *Activity*. Before this process, a script program has only one set of UI elements that cannot help it to determine which screen is showing. Because we want to provide more flexibility to our script, we build up auto-recognition mechanism in it so the script can choose next step by itself if the path went out of our expectation. With Activity form store in script, it can then record which component has been triggered or not. The Activity form plays a major role in path automation.

```xml
<?xml version="1.0" encoding="utf-8"?>
<LinearLayout android:gravity="center" android:orientation="horizontal" android:background="#ff42b7ff" android:layout_width="fill_parent" android:
layout_height="fill_parent"
  xmlns:android="http://schemas.android.com/apk/res/android">
    <LinearLayout android:gravity="center_horizontal" android:orientation="vertical" android:layout_width="wrap_content" android:layout_height="fill_parent
    " android:layout_weight="0.47">
        <Space android:layout_width="fill_parent" android:layout_height="150.0dip" />
        <ImageView android:id="@id/imageView1" android:layout_width="242.0dip" android:layout_height="253.0dip" android:src="@drawable/load_material_t2" />
        <TextView android:textAppearance="?android:textAppearanceLarge" android:textSize="50.0dip" android:id="@id/textView1" android:layout_width="
        wrap_content" android:layout_height="wrap_content" android:text="@string/text_system" />
        <LinearLayout android:gravity="center" android:layout_width="fill_parent" android:layout_height="250.0dip">
            <Button android:id="@id/ButtonActiveDemo" android:background="@drawable/ic_button1" android:layout_width="242.0dip" android:layout_height="150.
            0dip" />
            <Space android:layout_width="40.0dip" android:layout_height="fill_parent" />
            <Button android:id="@id/ButtonActiveRecord" android:background="@drawable/ic_button2" android:layout_width="242.0dip" android:layout_height="
            150.0dip" />
        </LinearLayout>
        <LinearLayout android:gravity="center" android:layout_width="fill_parent" android:layout_height="250.0dip">
            <Button android:id="@id/ButtonActivePlay" android:background="@drawable/ic_button3" android:layout_width="242.0dip" android:layout_height="150.
            0dip" />
            <Space android:layout_width="40.0dip" android:layout_height="fill_parent" />
            <Button android:id="@id/ButtonActiveCompare" android:background="@drawable/ic_button4" android:layout_width="242.0dip" android:layout_height="
            150.0dip" />
        </LinearLayout>
    </LinearLayout>
</LinearLayout>
```

Figure 9. Example of layout XML file

UI Automation Script

The final output of our purposed system, AndroAutoScript, is an UI automation script build up specifically according to each input Apk analysis result. The goal of the script program, as what we mentioned before, is to run automatic UI manipulation for an Apk and we want it to trigger as more UI component as possible. To visit every *Activity*, so, is necessary. We design the output of script and make the program be able to make a decision about next step. Considering there are plenty of event-driven code in Android applications, we may easily lose some connection when rebuilding its' control flow. It may cause unexpected steps when running an UI interaction script. If a straightforward script program took a wrong step that brings up unexpected Activity, it may then want to trigger next UI which does not even exist on the screen. For this reason, except automatic UI event triggering, we deploy features of Activity recognition and path recording in our output scripts.

The implementation of UI event trigger can be easily completed through monkeyrunner API. Digging in Apk file code and its resource files, we can get the set of UI objects and separate those are set interaction from static UI. There are objects' ids in hex format stated in the code. We then map these ids to its' Android declaration format, so they can be used in monkeyrunner API. Having ACG in our system, we set up UI event triggering with a pre-ordered sequence then the script program mainly follows the sequence and alters some steps if an exception occurred.

To deal with exception steps, we combine data of UI object collection and Activity form in AndroAutoScript to compose recognition list for each Activity. We use python dictionary to implement the recognition lists. With the lists, whenever the script program is going to trigger next UI object, it can determine if the component exists or not. For negative case, the program can match current screen using the recognition lists and choose another UI interaction object on the screen. By doing this we can ensure the program will not stop while exception.

Table 2. Implementation environment

AndroAutoScript	Dynamic Analysis Env
Ubuntu 14.04	Android SDK r24.1.2
Python 2.7.6	monkeyrunner
Androguard 1.9	Genymotion Emulator

Efficiency is another issue we care about. We want to provide an UI access method that can prevent repeat event especially when an exception happens. The recognition lists are used to record visited path as well. Once an interaction UI is triggered, the script program set a visit flag on its item in recognition list. Next time it comes to the same screen it will take some event has not been visited before. We state the implementation details in Section 4.

IMPLEMENTATION

In this section, we describe how we implemented AndroAutoScript in detail. Our goal is to build up an automatic script for Android application access. When the script program is run, the script runner should retrieve Activity nodes and trigger UI events as much as possible. Also, the program should possess the ability to make its own decision while encounters some unexpected steps.

Environment and Tools

Script generator

AndroAutoScript: AndroAutoScript is implemented in a mixture way with a shell script and python programs. We write a shell script in Ubuntu 14.04 operating system. The shell script automatically takes the apk file under the selected path to run the process. The script generator is a python program, and our python version is 2.7.6. We utilize several classes from an open-source tool, Androguard (version 1.9), and modify some of them to fit our system goal.

Script runner and emulator

We choose monkeyrunner, a tool belongs to Android SDK r24.1.2 for Linux, as our target script executor so that we can take advantages of the compatibility of monkeyrunner with Android framework and its well defined APIs. To run Android OS, Genymotion (Genymotion emulators, n.d.) emulator (version 2.4.0) is put up for verification purpose. Genymotion provides a fast virtual machine accomplished on the base of Oracle VirtualBox.

AndroAutoScript

As **Figure 10** shows, once AndroAutoScipt receives an Apk input, it will, firstly, extract this Apk's data of disassembling code and XML resources files. We import python objects that decode Apk files and analyses Dalvik VMs from Androguard (Androguard, n.d.) to help the process. With these informations, we can go on analyzing ACG.

Graph analysis

For dealing control flow graph with Android applications, we can apply Function Call Graph (FCG) approach at the beginning. We go through the code and make each function/method a node, function call as directed edge to build up its FCG. Therefore, we get a directed graph which contains several distributed subgraph like **Figure 11**.

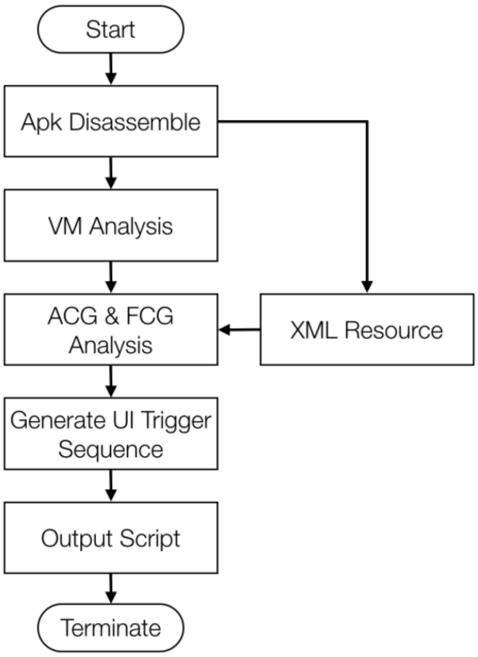

Figure 10. AndroAutoScript Work Flow

Green nodes indicate Activities' onCreate() methods and Brown ones are UI listener methods. We arrange the graph manually to show the direction of control flow in a top-to-bottom fashion. It can easily be found that there are separations before every UI event listener. Although we align UI listeners with their own object initializing methods, these connections cannot be traced through a function call. Because once an UI event listener is set, Android will take care its trigger calls. Bringing up *Activities* is another implicit call in Android. One may use *startActivity()* or *startActivityForResult()*method to start a new activity in Android application program. We need to build up these connections before we use utilize control flow to establish a script generator.

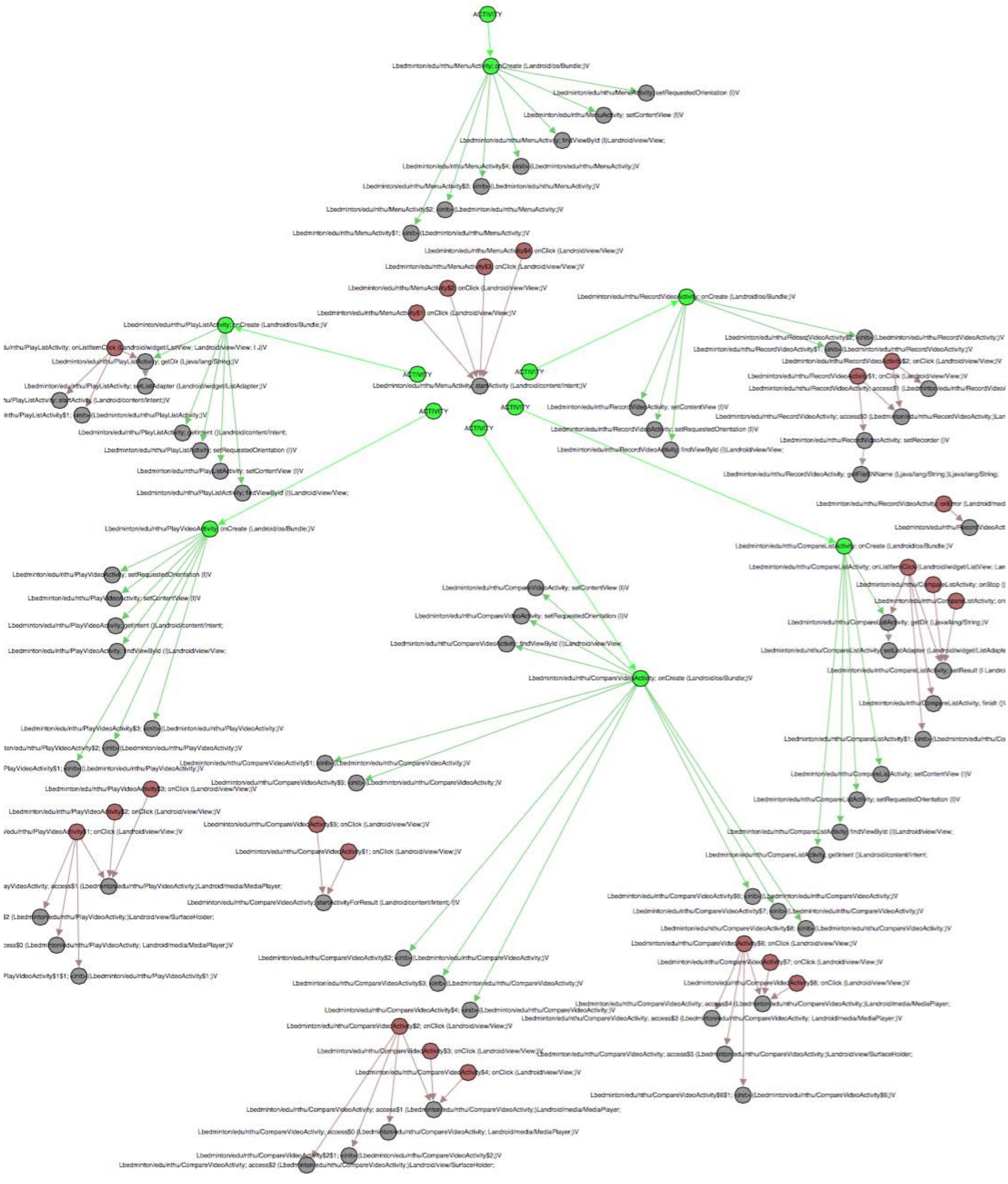

Figure 11. Android application function call graph

Digging into Apk code, we can find our desired information. We focus on code where declares UI listeners and function of on-event-triggered part. UI listener declaration contains instance name of the new-declared listener object. In our sample, such declaration could be this.ButtonActiveDemo.setOnClickListener(new bedminton.edu.nthu.MenuActivity$1(this));. Here UI listener instance name is "bedminton.edu.nthu.MenuActivity$1" and it is named by Android compiler's rule. The rule is that every listener declaration will be named with prefix of its caller class package name. That means this listener, which is a button listener, is declared in an Activity named MenuActivity. Having the object name, we can bind up the initial node with on-event-triggered node.

```
    def trace_node_by_UI_code(self, method, sourceCode):      # Steve
        actvyList = []
        if "onClick" in method.get_name():
            self.append_trace_list(sourceCode, actvyList)
        if "onListItemClick" in method.get_name():
            self.append_trace_list(sourceCode, actvyList)

        if len(actvyList) > 0:
            # print len(actvyList)
            return actvyList
        else:
            return None

    def append_trace_list(self, sourceCode, actvyList):
        if "startActivity" in sourceCode:
                # print sourceCode
                varNames = self.find_variable_of_startActivity(sourceCode)
                # print varNames
                for varName in varNames:
                    classNames = self.find_className_by_variableName(varName, sourceCode)
                    for className in classNames:
                        classInfo = className, "onCreate", "(Landroid/os/Bundle;)V"
                        actvyList.append(classInfo)

    def find_variable_of_startActivity(self, sourceCode):    # Steve
        variableNames = []
        for line in sourceCode.split('\n'):
            if "startActivity(" in line:
                params = self.extract_params_from_method("startActivity(", line)
                variableName = params[0]
                if (variableName != None) & (variableName not in variableNames):
                    # print variableName
                    variableNames.append(variableName)
            if "startActivityForResult(" in line:
                # print line
                params = self.extract_params_from_method("startActivityForResult(", line)
                variableName = params[0]
                if (variableName != None) & (variableName not in variableNames):
                    # print variableName
                    variableNames.append(variableName)
        # print variableNames
        return variableNames
```

Figure 12. Function that deal with startActivity()

There is some additional information we can get from this part of process. We can find id of those UI variable in code before setting up listeners. For the same example, line of "this.ButtonActiveDemo = this.findViewById("0x7f05000c");" is found stated in front of the previous code. A hexadecimal id is assigned to this button and registered in the application. This id will be used later while our script has to figure out UI components form screen.

```python
    def match_variables(self, sourceCode):
        tempMatches = dict()
        # setOnItemClickListener usually don't appear with findViewByID
        matches = dict()
        for line in sourceCode.split('\n'):
            if "findViewById" in line:
                params = self.extract_params_single_const("findViewById(", line)
                idStr = params[0]
                # print "findViewById: ", idStr, line   # debug
                idint = 0
                try:
                    idint = int(idStr,16)
                except ValueError:
                    print "Value error: ", idStr
                    continue
                arsc = self.apk.get_android_resources()
                idAlian = '/'.join(arsc.get_id(self.apk.get_package(),idint)[0:2])
                # print idAlian # debug
                var = self.strip_variable_from_top(line, " = ")
                if idAlian not in tempMatches.values():
                    tempMatches[var] = idAlian
            if "setOnClickListener" in line:
                params = self.extract_params_from_method("setOnClickListener(", line)
                param = params[0]

                # ;;; if occurs "setOnClickListener(this)" it should return self class in match
                className = self.strip_prefix_and_suffix(param, "new ", "(this)")
                LclassName = 'L'+'/'.join(className.split('.'))+';'
                # print "setOnClickListener class: ", LclassName, line # debug
                var = self.strip_variable_from_top(line, ".setOnClickListener")
                if var in tempMatches.keys():
                    matches[LclassName] = tempMatches[var]
            if "setOnItemClickListener" in line:
                params = self.extract_params_from_method("setOnItemClickListener(", line)
                param = params[0]
                className = self.strip_prefix_and_suffix(param, "new ", "(this)")
                LclassName = 'L'+'/'.join(className.split('.'))+';'
                # print "setOnItemClickListener class: ", LclassName, line # debug
                var = self.strip_variable_from_top(line, ".setOnItemClickListener")
                if var in tempMatches.keys():
                    matches[LclassName] = tempMatches[var]
        return matches
```

Figure 13. Function that extracts id

The other connection we need to rebuild is Activity call. If one on-event-triggered method, for instance *onClick()*, will lead the application to another screen, it would call *startActivity()* to do so. A called Activity name will not show directly in the statement of startActivity() method, instead, one should use an *Intent* object to carry Activity name into use. Intent is a class used to bring detail information of system action, like a message pack in Android framework. We can still retrieve called Activity name in line of Intent declaration and then build up the connection between UI object a target Activity. As what we stated above, we modify FCG approach to construct a complete graph that is shown in **Figure 14**. Note that not every UI event listener involves Activity switch. Some of the UI trigger only computational function, and we also get those behavior in the graph. Our output script is provided with complete information of the UI objects.

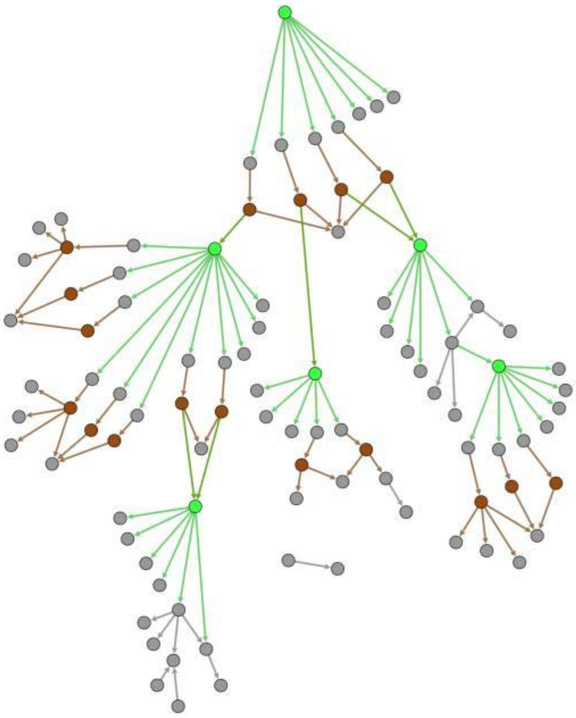

Figure 14. Modification of function call graph on Android application

Now we have finished the Activity call graph. This graph is utilized to form a UI automation sequence in output script. Using deep first traversal algorithm, AndroAutoScript makes an UI-trigger sequence that starts from mainActivity, the beginning of every Android application, and then visits every UI components in ACG.

```
def custom_process_01(self):
    idClickMatches = dict()
    onClickInfo = []
    for method in self.vm.get_methods():
        mx = self.vmx.get_method(method)     # Does it possible get classes? vm.get_classes()?

        if method.get_code() == None:
            continue

        ms = decompile.DvMethod(mx)
        ms.process()
        methodSourceCode = ms.get_source()

        matches = self.match_id_with_onClickListener(method, methodSourceCode)
        # print matches
        if len(matches) > 0:
            idClickMatches.update(matches)

        parentClassName, parentMethod, parentDescriptor = self.extract_ui_parent_method(method)
        if parentMethod != None:
            # print parentClassName, parentMethod, parentDescriptor
            info = method.get_class_name(), method.get_name(), method.get_descriptor()
            onClickInfo.append(info)

            n1 = self._get_exist_node(parentClassName, parentMethod, parentDescriptor)
            n2 = self._get_exist_node(method.get_class_name(), method.get_name(), method.get_descriptor())
            if (n1 != None) & (n2 != None):
                self.G.add_edge(n1.id, n2.id)

        actvyList = self.trace_node_by_UI_code(method,methodSourceCode)
        if actvyList != None:
            # self.print_paths_method(method)
            for actvyClassName, actvyMethod, actvyDescriptor in actvyList:
                n1 = self._get_exist_node(method.get_class_name(), method.get_name(), method.get_descriptor())
                n2 = self._get_exist_node(actvyClassName, actvyMethod, actvyDescriptor)


                if (n1 != None) & (n2 != None):
                    self.G.add_edge(n1.id, n2.id)
                if n1 == None:
                    print method.get_class_name(), method.get_name(), method.get_descriptor(), "[[not found]]"
                    print actvyClassName, actvyMethod, actvyDescriptor
                if n2 == None:
                    print method.get_class_name(), method.get_name(), method.get_descriptor()
```

Figure 15. Function rebuild the connection

XML resources file

Inside XML resources file in Apk, we can extract string id for each UI objects. After be packaged by Android IDE tools, ids in Apk code are transformed into hexadecimal as we stated in Section 4.2.1. We have to convert these ids into string form so they can be used in a monkeyrunner script. All XML resources file are archived in one ARSC format file inside an Apk. We then access the file by an ARSC parser. **Table 1** shows an example of public.xml file. It contains the mapping of string and hexadecimal version of UI object id. We implement the transform in 394 AndroAutoScript according to the file.

Android apps also store layout of each Activity in XML files. Layout files describe hierarchical structure of each screen that has been used. AndroAutoScript read these file to divide UI objects from different Activities. Output scripts will have a set of UI list sorted by Activities. This information is written into python dictionary form in scripts.

```
activityUIdic = {\
"MenuActivity":{"id/ButtonActiveRecord":None, "id/ButtonActiveCompare":None, "id/ButtonActiveDemo":None},\
"PlayVideoActivity":{"id/buttonPlay":None,"id/buttonPause":None,"id/buttonStop":None},\
"RecordVideoActivity":{"id/record_start":None,"id/record_stop":None},\
"CompareVideoActivity":{"id/button_cp_up_play":None,"id/button_cp_up_pause":None, "id/button_cp_up_stop":None,
"PlayListActivity":{"@android:id/list":None},\
"CompareListActivity":{"@android:id/list":None},\
}
```

Figure 16. Activity form in script

Script Program

The final output of AndroAutoScript is a python code file which is an executable monkeyrunner script program. Considering unexpected events may occur, we design the script with a more flexible process. Beside a UI automation sequence that we obtain through ACG analysis in AndroAutoScript, the script has alter steps if something goes wrong. Following the work flow of our script program, **Figure 17**, we explain the details. When the script program start, first, it loads data that AndroAutoScript gives. The data contains a UI trigger sequence which gives basic execution steps for application automation. We store the sequence with python dictionary (**Figure 18**) and put additional attributes such destination and source Activity or visited flag for recording visited path. The script read steps from sequence data in a loop. Every time it gets an UI object id, script program checks if the object is visible on the screen. Monkeyrunner provide a class, EasyMonkeyDevice, from com.android.monkeyrunner.easy package helps this job. It has easy device.visible() method can check there is the certain UI object or not. If the object exists, we can trigger the UI event immediately and set visited flag in sequence.

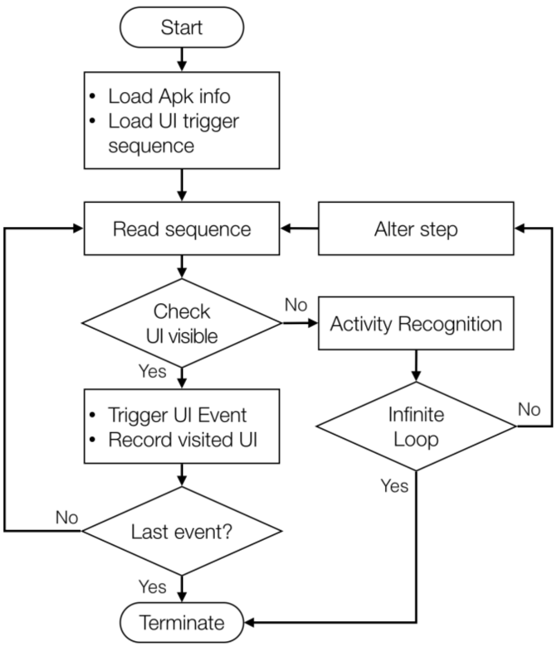

Figure 17. Script Program Work Flow

```
triggerSequence = {\
1 : {"type":"UI", "strID":"id/ButtonActiveRecord", "currentActivity":"MenuActivity", "nextActivity":"RecordVideoActivity", "visited":None},\
2 : {"type":"UI", "strID":"id/record_start", "currentActivity":"RecordVideoActivity", "nextActivity":None, "visited":None},\
3 : {"type":"UI", "strID":"id/record_stop", "currentActivity":"RecordVideoActivity", "nextActivity":None, "visited":None},\
4 : {"type":"dev", "devKey":"KEYCODE_BACK", "currentActivity":"RecordVideoActivity", "nextActivity":"MenuActivity", "visited":None},\
5 : {"type":"UI", "strID":"id/ButtonActiveCompare", "currentActivity":"MenuActivity", "nextActivity":"CompareVideoActivity", "visited":None},\
6 : {"type":"UI", "strID":"id/button_cp_down_choose", "currentActivity":"CompareVideoActivity", "nextActivity":"CompareListActivity", "visited":None},\
7 : {"type":"dev", "devKey":"KEYCODE_BACK", "currentActivity":"CompareListActivity", "nextActivity":"CompareVideoActivity", "visited":None},\
8 : {"type":"UI", "strID":"id/button_cp_down_stop", "currentActivity":"CompareVideoActivity", "nextActivity":None, "visited":None},\
9 : {"type":"UI", "strID":"id/button_cp_down_pause", "currentActivity":"CompareVideoActivity", "nextActivity":None, "visited":None},\
10 : {"type":"UI", "strID":"id/button_cp_up_choose", "currentActivity":"CompareVideoActivity", "nextActivity":"CompareListActivity", "visited":None},\
11 : {"type":"dev", "devKey":"KEYCODE_BACK", "currentActivity":"CompareListActivity", "nextActivity":"CompareVideoActivity", "visited":None},\
12 : {"type":"UI", "strID":"id/button_cp_up_pause", "currentActivity":"CompareVideoActivity", "nextActivity":None, "visited":None},\
13 : {"type":"UI", "strID":"id/button_cp_down_play", "currentActivity":"CompareVideoActivity", "nextActivity":None, "visited":None},\
14 : {"type":"UI", "strID":"id/button_cp_up_stop", "currentActivity":"CompareVideoActivity", "nextActivity":None, "visited":None},\
15 : {"type":"UI", "strID":"id/button_cp_up_play", "currentActivity":"CompareVideoActivity", "nextActivity":None, "visited":None},\
16 : {"type":"dev", "devKey":"KEYCODE_BACK", "currentActivity":"CompareVideoActivity", "nextActivity":"MenuActivity", "visited":None},\
17 : {"type":"UI", "strID":"id/ButtonActivePlay", "currentActivity":"MenuActivity", "nextActivity":"PlayListActivity", "visited":None},\
18 : {"type":"dev", "devKey":"KEYCODE_BACK", "currentActivity":"PlayListActivity", "nextActivity":"MenuActivity", "visited":None},\
19 : {"type":"UI", "strID":"id/ButtonActiveDemo", "currentActivity":"MenuActivity", "nextActivity":"PlayListActivity", "visited":None},\
}
```

Figure 18. Example of UI automation sequence

While false condition, the script will go to alter step branch. It can be a situation that, in our example (**Figure 19**), our script brings up an unexpected Activity or Android application occurs error so comes up with an alert dialog. The script then starts the Activity recognition feature to determine current screen. Then program chooses a step inside the sequence that is not executed and belongs to current Activity to continue the script procedure. In system alert dialog case, we can learn the "ok" or "cancel" button in default UI list. Default UI object normally comes with simple string id such as id/button1 to id/button3. In case the script program keep comes in alter step at same point, we set a threshold execution count. Once the counter goes over the threshold in taking alter step, we terminate the script.

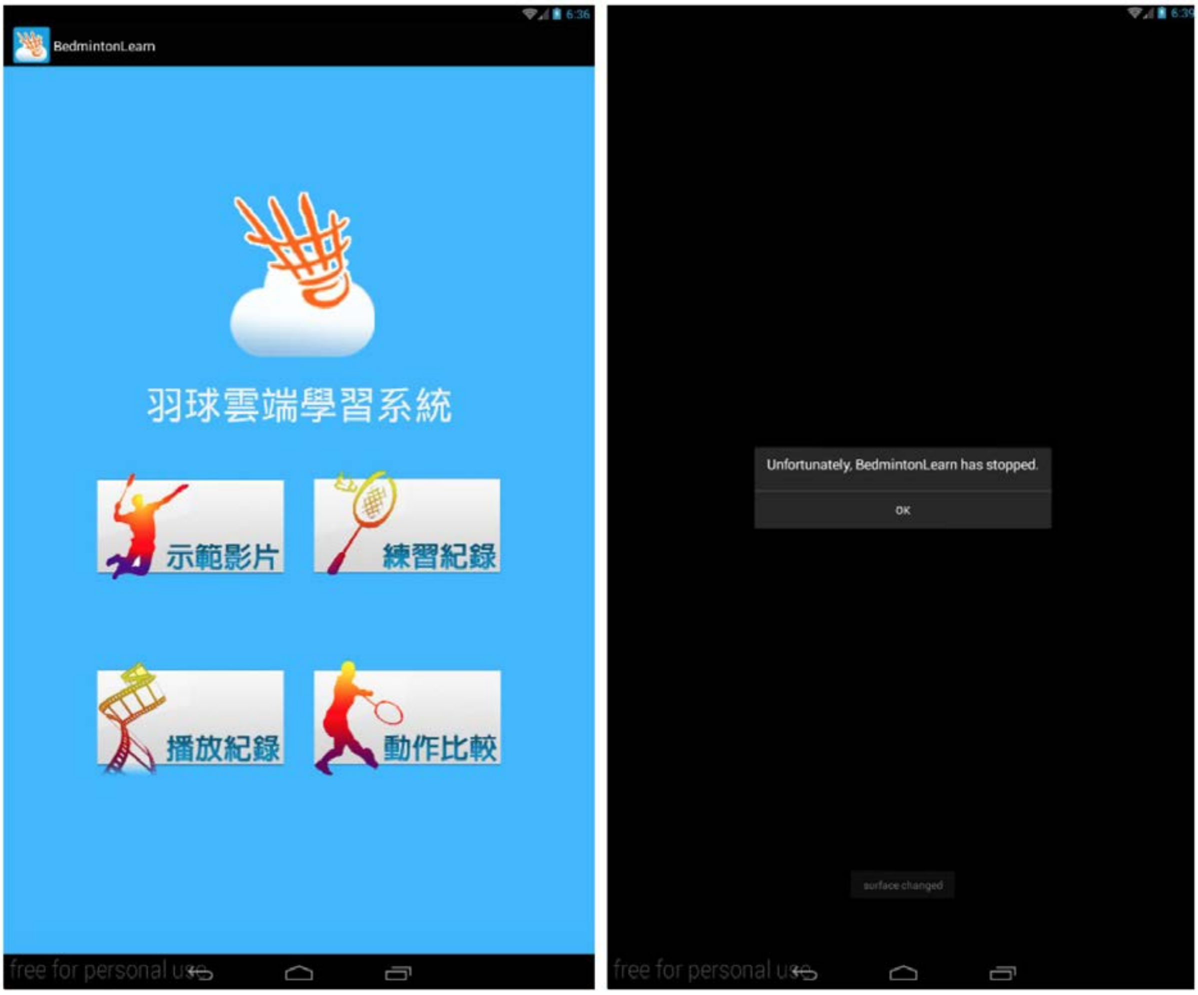

Figure 19. (a) Example application (b) On alert dialog

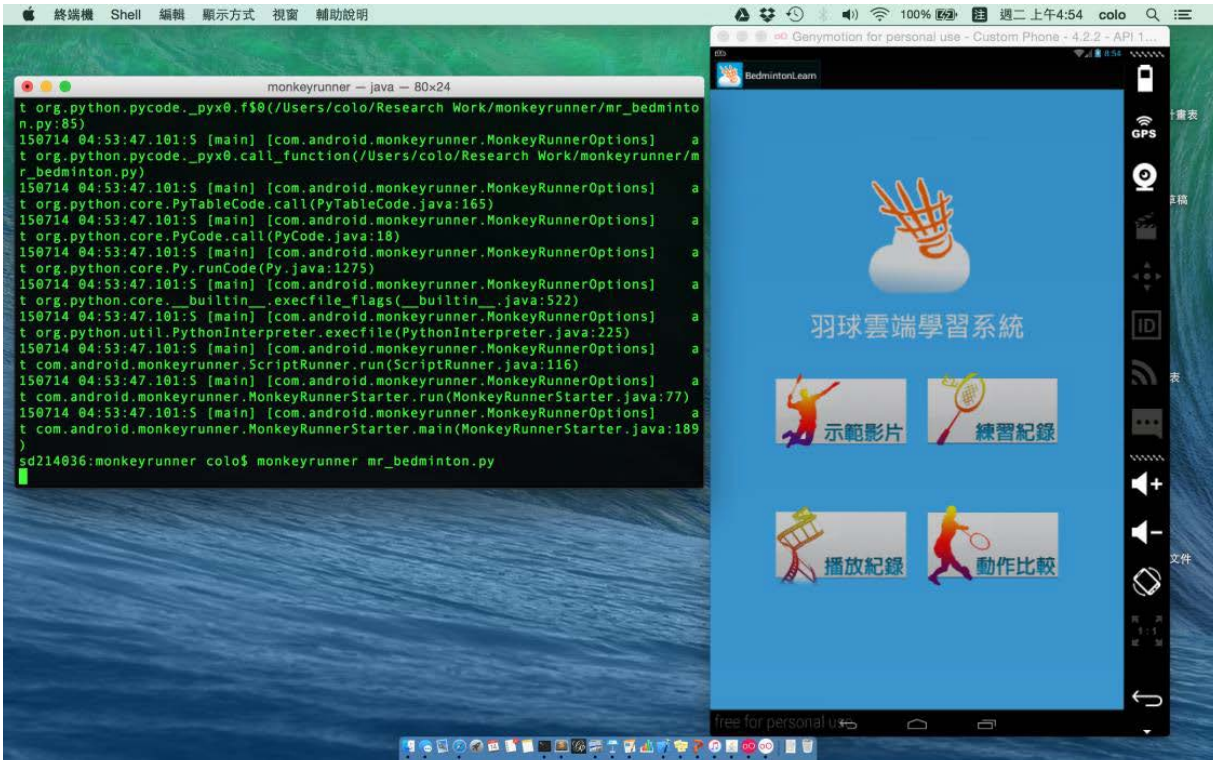

Figure 20. Screenshot of execution (A)

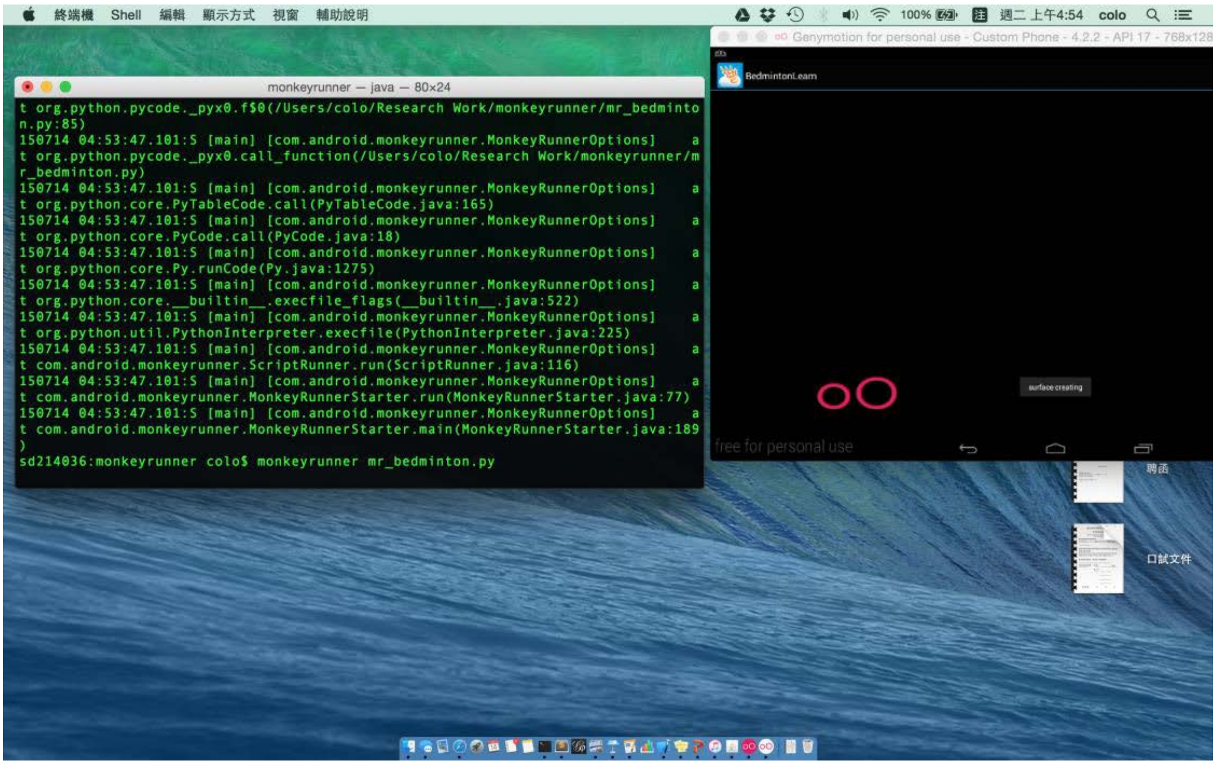

Figure 21. Screenshot of execution (B)

ANALYSIS

In this section, we use an experiment to evaluate our proposed system - AndroAutoScript. Monkey is the most generally used automatic tool that has been deployed in dynamic analysis environment. Our goal is to exam the efficiency of the automatic systems. We use the index of application coverage and the execution time. The example applications have multiple Activities and some of them have complex Activity call structure that can confuse the automation mechanism if the system has no structure information. Because our approach covers limited UI objects, for those UI we cannot deal with we use substitute UI. Most of the Android apps are developed following certain structure in feature of procedure way, we choose ten apps and use substitute UI in new apps to simulate their structure. And we slightly refine our script by each sample for smooth the procedure.

Table 3. Experimental result

Approach/Apps		**Monkey**		**AndroAutoScript**
Coverage	**Time**		**Coverage**	**Time**
Tree-type I	100%	1m 53.192s	100%	5.118s
Tree-type II	100%	1m 43.720s	100%	9.428s
Master-detail-type I	100%	2m 46.668s	100%	5.916s
Master-detail-type II	100%	1m 16.392s	100%	11.968s
Master-detail-type III	89.5%	3m 43.536s	100%	24.644s
Tab-type I	100%	8m 04.460s	100%	14.268s
Tab-type II	77.8%	6m 20.340s	100%	17.856s
Tab-type III	100%	9m 28.752s	100%	31.756s
Loop-type I	76.9%	9m 51.588s	100%	14.214s
Loop-type II	73.2%	22m 43.952s	100%	2m 1.368s

Table 4. Monkey command

```
adb shell monkey --ignore-crashes --ignore-security-
exceptions --ignore-timeouts --pct-touch 70 --pct-
syskeys 0 --pct-anyevent 0 --pct-motion 0 --pct-
appswitch 0 -v -v -v --throttle 30 -s 2000 –p
com.example.test.appalph 50000
```

We catalog these apps into different types. Tree-type means the app has simple tree process path. Master-detail type apps have a main list on starting interface. Clicking on each list item, the app will show its detail. Tab type obtains a row of tab icons and each one represents its own page while touched. Some apps have process structure too complicated that has loops in its process, we put them into loop type apps. We then compare our generated script executing monkeyrunner with monkey's random stream, the result shows in **Table 3**. Coverage stands the percentage of numbers of Activity that have been displayed during the experiment.

Result

We compare AndroAutoScript with Monkey the Android debug bridge tool which is set to trigger app UI fifty thousand times. AndroAutoScript runs an app and ends once it goes through all nodes in the graph. On the other way, because fifty thousand triggers of Monkey can repeat some actions several times, we record its process time by getting rid of redundant steps.

The result shows our approach can precisely reach each Activity it knows from the app's information and uses a trigger-save way to finish it. While Monkey did fifty thousand triggers for each app, it can be trapped by some sophisticated structure like a loop, and takes longer to reach full visiting.

Case Study

As what we mentioned before, the automatic mechanism on dynamic analysis needs to efficiently reach every corner of an application. We choose one of the loop type apps to show both behavior of Monkey and AndroAutoScript on Activity visiting. Our experiment runs both automation of monkey and AndroAutoScript on the sample app, and record the Activity visit count during execution. The Activity visit count can be on behalf of execution coverage of the app. The more activity we visit the more procedure of program we reach. Our result shows in **Figure 22** and **Figure 23**.

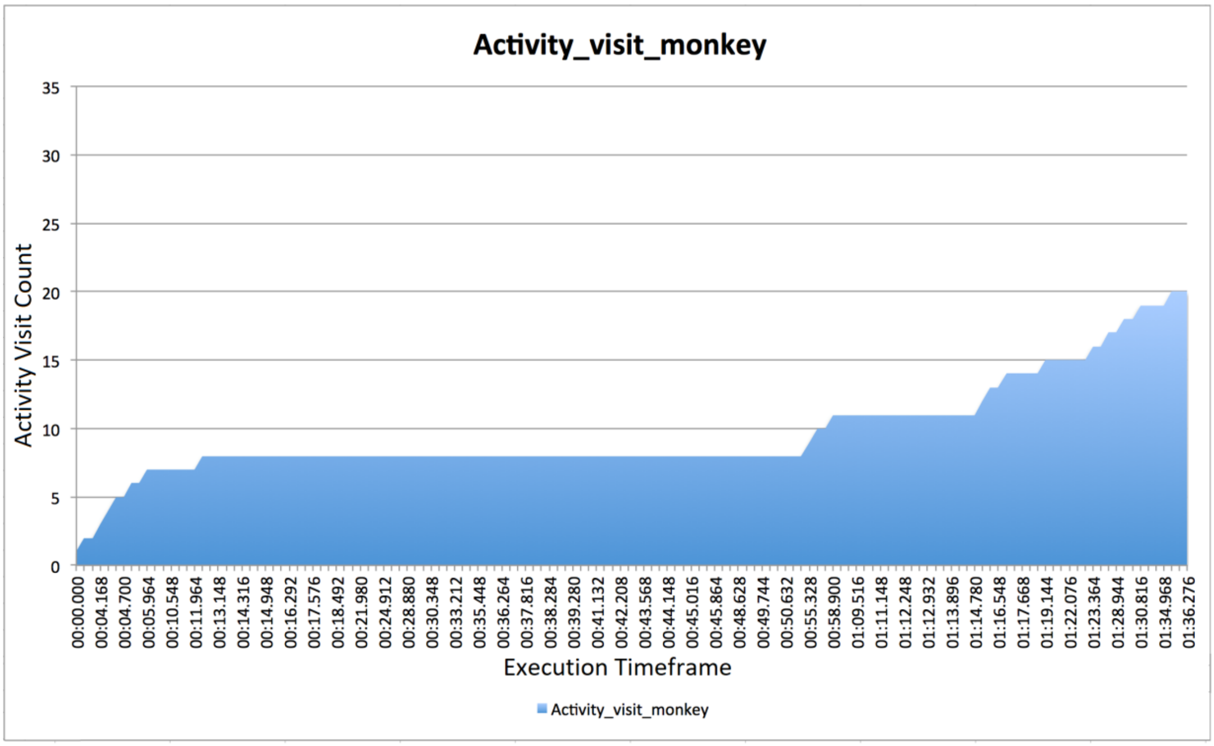

Figure 22. monkey performance on visit Activity

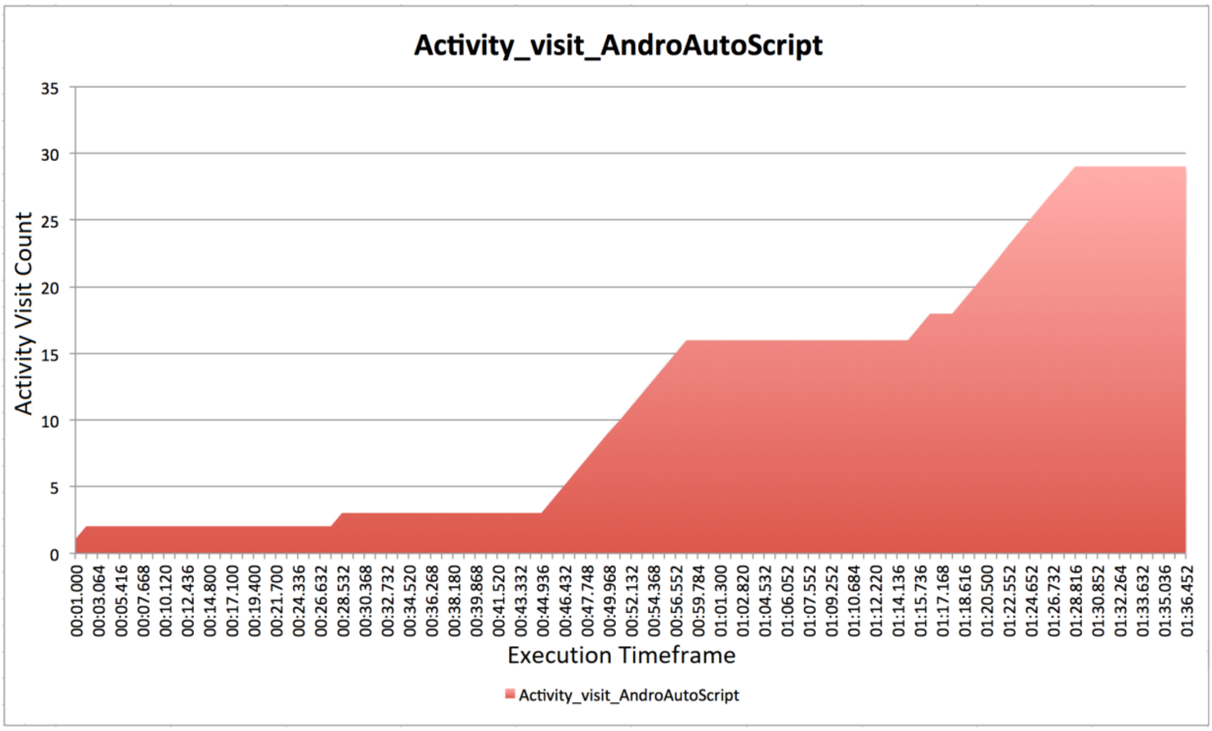

Figure 23. AndroAutoScript performance on visit Activity

Discuss

In our result of the experiment, we can see the Activity visit count on both approaches in a period of ninety seconds. Monkey executes very fast UI triggering that increase the visit count rapidly in the first ten seconds. In this period Monkey visits almost three times Activities as our system. The script our system generated follows the structure of UI and Activity call in the application. It triggers each UI component step by step. That cause our visit rate seems to stay low at the start. About forty-five second, AndroAutoScript enters another part of the program which concentrated on Activity usage. The visit count, then, increases steadily when triggering nearby new Activities one-by-one.

At the same time, monkey encounter the bottleneck and visit rate stops growing. Monkey generates random stream that may be trapped inside a loop calling structure and hardly trigger each UI in a multiple-component interface. Although we set command to reduce the system-key-event in monkey, it would sometimes distracted by *BACK* key or other system event. In other words, we can say random trigger stream calls Activities by fortune. On the contrary, AndroAutoScript follows the calling structure and it can steadily and sequentially go through every part of a program.

According to our experiment, our approach can efficiently reach most parts of an application. Monkey, however, would take a lot of time trapped in some calling structure that may slow down the automation progression.

CONCLUSION

In this work, we propose an approach to Android application UI automation. Our motivation is to reduce the human resource cost while execution dynamic analysis on Android applications. Our method combines the information of disassembled code and XML resources file in Apk to build up an automation script. And we choose Android SDK tool, monkeyrunner, as our script executor.

There are other excellent approaches to Android UI automation such as DroidTrace (Zhen et al., 2014) deploy a method called "forward execution". They utilize Apk repackaging technique, insert UI event trigger code after every UI listener setting to fulfill automation. SmartDroid (Zheng et al., 2012) take a mixed approach with both static and dynamic method. Unless analyze ACG with static Apk data, they further make modification on Android emulator to catch implicit call inside Android OS.

The advantage of our approach is that it takes low effort in implementation. We do not need to modify Apk and repackage it neither need to modify Android emulator. Also, we include monkeyrunner in our framework, so this approach can easily transmit in between different version. Our approach takes exception in UI automation into consideration. The alter step setting can increase the integrity of script execution.

Author Contributions: Yining Liu and Hung-Min Sun conceived and designed the experiments; Shih-Chi Wang performed the experiments; Yang Yang analyzed the data; Yeh-Cheng Chen contributed reagents/materials/analysis tools; Shih-Chi Wang wrote the paper; Yining Liu revised the paper.

Conflicts of Interest: The authors declare no conflict of interest. The founding sponsors had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, and in the decision to publish the results.

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Students' Satisfaction and Factors in Using Mobile Learning among College Students in Kuwait

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ABSTRACT

Mobile learning (ML) technology and its services have provided a new platform for higher education institutions to enhance the learning process. Mobile learning provides learners with flexibility and ubiquity. However, students' satisfaction and factors of using ML in private and public universities remain academically unexplored. In this study, the constructivism learning theory was applied to investigate students' satisfaction and the factors that predict the use of ML among public and private university students in the learning process. The researchers developed a questionnaire with 43 items to gather information about the degree of students' satisfaction and factors in using mobile learning among college students for both public and private universities in Kuwait. A sample of 1,012 undergraduate students were randomly selected from three different universities in Kuwait. The study was conducted in the second semester of 2015/2016. The results showed that females were more likely to be satisfied with smartphones for educational purposes than males and that Kuwaiti students tend to be more satisfied with smartphones for educational purposes than non-Kuwaiti students. Factors used to predict students' satisfaction with ML were Internet speed, smartphone portability, smartphone skills, screen size, gender, nationality, and college. The researchers suggest expanding the current study to include graduate students.

Keywords: Kuwait, learning satisfaction, Mobile learning (ML), smartphones, college students

MOBILE LEARNING IN HIGHER EDUCATION INSTITUTIONS IN KUWAIT

There has been a considerable increase in the use of mobile devices such as smartphones all over the world (Astin, 1993; Ichikawa, Chipchase, & Grignani, 2005; Liaw, 2008; Wali, Winters, & Oliver, 2008). By the end of 2018, an estimated 1.4 billion smartphones will be in use, according to a new study by ABI research (Leonard, 2013), and with a world population of 7 billion, this means one smartphone for every five people. This increase in the number of smartphone devices has steered researchers to focus on using such devices as a tool to support teaching and the learning process (Koszalka & Ntloedibe-Kuswani, 2010). According to Ichikawa et al. (2005), the three things that people most frequently carry are keys, wallets, and phones. In this work, the researchers study the importance of smartphones for students for academic purposes. McQuiggan, Kosturko, McQuiggan, and Sabourin (2015) quoted Franklin Delano Roosevelt who stated that "we cannot always build the future for our youth, but we can build our youth for the future" (p.1). Mobile technology offers features that enable it to break the educational system wide open, involving students in new ways and making educational experiences more profound, if higher educational institutions can effectively utilized structured, integrated approaches for implementations of mobile technology (McQuiggan et al., 2015). Smartphones have changed many aspects of our lives, especially education. Wang, Shen, Novak, and Pan (2009) have stressed the importance of interactivity between and among students and teachers. They state that many online classes simply provide recorded lectures, which only reinforces the negative effects of passive, non-participatory learning. In their study, which involved a blended English classroom of 1,000 students

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Contribution of this paper to the literature

- The findings of the present study help faculty members to reconsider their teaching style and adopt ML to keep pace with technological developments.
- The results of current study help decision makers in higher education institutions to engage ML into educational process in effective manner.
- The results of the current study enhance the research field of educational technology by exploring the factors (technical and demographics) that best predict the level of satisfaction among undergraduate students who use ML.

(800 being online), they showed that ML activities enhanced students' engagement in the classrooms and switched students from being passive learners to being truly engaged learners who are behaviorally, intellectually, and emotionally involved in their learning tasks. According to the American Distance Education Consortium (ADEC), student satisfaction "is the most important key to continue learning" (para. 5) (Bolliger & Wasilik, 2009). Student satisfaction is defined as a student's perceived value of his or her educational experiences at an educational institution (Astin, 1993) or how comfortable the user feels with the educational systems to achieve his or her goals (Alqahtani & Mohammad, 2015). In the field of human-technology interaction, Alqahtani and Mohammad (2015) reported that user satisfaction refers to the feelings of affection experienced by interacting with the system; consequently, satisfaction is a subjective set of interactive experiences influenced by effective elements. Successful implementation of ML is frequently measured by students' satisfaction (Sachs & Hale, 2003). Several components influence student satisfaction in an ML environment. The instructor, technology, and interactivity are the three key factors that affect students' satisfaction when using smartphones in ML (Bolliger, 2004). Additional factors that affect satisfaction are communication with course constituents and management systems used. Moreover, students' perceptions of tasks' value and self-efficacy, social ability, quality of systems, and multimedia instruction have been identified as critical components (Liaw, 2008). In the next section, the researchers discuss the definitions of smartphones (SP) as a critical factor for mobile learning.

DEFINITIONS OF SMARTPHONES (SP)

To define smartphones (SP), it is crucial to understand the definitions of mobile learning (ML). Many studies define ML differently based on their interests. Early definitions of ML focused on technological tools; later, the focus shifted to mobility, where the learning as well as the acquisition of knowledge and skills is not restricted to a fixed place or time. Recently, performance has become important in ML. "Performance" refers to any activity that allows an individual to be more productive when consuming, interacting, or creating information using a mobile device (Driscoll & Van Barneveld, 2015). Moses (2008) defines ML as a form of e-learning that involves the use of a mobile device, such as a smartphone, to produce learning experiences anywhere and anytime to meet the needs of different learners. By contrast, Peng, Su, Chou, and Tsai (2009) use Hummel and Hlavacs' definition of ML:

> *"A situation in which a multitude of connected and embedded systems and devices work together to build an ambient computing allows people both to access learning content from anywhere at any time, and to communicate with colleagues or lecturers synchronously and asynchronously much more frequent" (p.6).*

Peng et al. (2009) interpreted ML as "widespread" and extending beyond the simple notion of "anytime, anywhere learning" to also include learning "the right thing" at "the right time" at "the right place". The Oxford English Dictionary defines a smartphone as "any of various telephones enhanced with computer technology." The term "smartphone" later came to refer to a phone "typically with a touch-screen interface and Internet access" (Brenner, 2013).

Dikkers (2012) defines mobile learning as including instant and active connection to online information to promote personal growth and increased communication within professions and communities. Thus, immediate access to information would satisfy students, which will positively be reflected in their learning process. In this study, the researchers will use this definition to explain how access to information enhances students' satisfaction.

Smartphones typically include cell-phone features in addition to other features that are popular in other mobile devices, such as personal digital assistants, media players, and GPS navigation units. Most smartphones have a touchscreen interface, a camera, high-speed cellular data connectivity, and motion sensors, in addition to various application programs. Mobile operating systems include Android, IOS, Firefox, Sailfish, Tizan, Ubuntu Touch, BlackBerry, Symbian, Windows Mobile, Balm OS, and Bada. Applications (or "apps") are software programs designed to run on smartphones. Most mobile service providers in Kuwait offer 4G+ and LTE-Advanced connections delivering high-speed data communication. 4G LTE is an abbreviation for the fourth-generation long-term evolution of the wireless communication standard used for high-speed data for mobile phones and data terminals (Brenner, 2013; Peng et al., 2009). In the next section, the researchers discuss the constructivism theory and its implications for ML.

CONSTRUCTIVISM THEORY

The concept of constructivism is that learning is an active process in which learners construct new ideas according to their current and past knowledge (Bruner, 1966). Constructivism is a very broad theory, and it has several aspects, such as radical, social, physical, evolutionary, postmodernist, information-processing, and cybernetic (Murphy, 1997). This study focuses on the social interaction part, since ML provides excellent interaction with the environment. As knowledge continues to raise, access to what is needed is more critical than what the learner currently seizes. Social constructivism presents a model of learning that acknowledges the tectonic shifts in society where learning is no longer an internal, individualistic activity (Siemens, 2005). Siemens wondered how students' functioning is altered when new tools such as ML are utilized. Siemens also added that constructivism provides insight into the learning skills and tasks needed for learners to grow in a digital era. Constructivism focuses on creating a learning environment that centers learners in constructing the meaning of what they are learning and socially negotiating that meaning with peers. In constructivist theory, learning should be designed so as to be authentic, relevant, immersive, and contextual, where learners are actively involved in the learning process and are supported by instructors with scaffolding and metacognitive cues (Driscoll & Van Barneveld, 2015, p. 9).

Bruner (1966) states that both the teacher and the student should engage in an active dialogue to translate information to be learned into a format appropriate to the learner's current state of understanding. One major characteristic of the constructivism learning theory is that motivation and satisfaction are key components in learning (Hein, 1991); thus, constructivists argue that individuals' motivations and satisfaction greatly affect their abilities to learn. The most basic motivation for and satisfaction of learning is an individual's desire to make sense of the world (Hein, 1991).

Sawang, Newton, and Jamieson (2013) tested three areas of e-learning and their impact on learners' satisfaction: (1) levels of technological efficiency, (2) authenticity and complexity and (3) organizational support. The results supported previous hypotheses and suggested that certain learners' characteristics and e-learning characteristics, such as authenticity, significantly contributed to learners' satisfaction with e-learning. Furthermore, the results supported the fact that learners are more satisfied when e-learning includes authentic activities, which is congruent with the constructivist learning theory.

Several studies discuss how constructivism can be adapted to new technologies such as ML. Bada (2015) suggests that teaching with new technology can promote students' active construction of an internal representation of knowledge by interacting with the information to be learned. Lunenburg (2011) says that teachers should engage students with contradicting hypotheses and then encourage discussion. Due to its ability to provide rapid interaction and feedback, ML is very well suited to keep students engaged in discussions.

Technology and tools such as ML provide opportunities for students to explore a variety of attitudes so they can construct their own knowledge of various concepts (Rice & Wilson, 1999). Such tools have shifted the focus from "knowledge-as-possession" to "knowledge-as-construction" and from "outside-guided" learning to "self-guided" learning (Rice & Wilson, 1999, p. 6). Such a shift, implied in ML, is compatible with constructivism's learning principles. Constructivism and technology tools have reshaped the conception of learning challenges and brought new learning possibilities for almost all teaching and learning situations, including the mobile learning environment. Mobile learning brings new opportunities and improves student-teacher communication (Al-Fahad, 2009).

The objectives of the study can be stated as follows:

(1) Measure both public and private university students' degree of satisfaction with using smartphones in the learning process in the State of Kuwait.

(2) Investigate any differences in satisfaction based on students' gender, nationality, grade point average (GPA), and college attended for both public and private universities.

(3) Explore the factors, both technical and demographic, that best predict the satisfaction among students who use ML.

The importance of the study findings can be summarized as follows:

- Help decision makers in higher education institutions to effectively incorporate ML into the educational process.
- Entice faculty members to reconsider their teaching style and adopt ML to keep pace with technological developments.

- Contribute to the employment of educational mobile devices in higher education.
- Bridge the gap between theory and practice.

Problem of the study:

Since the students' satisfaction and factors of using ML in private and public universities remain academically unexplored, the study addressed the following questions:

Q1: What is the difference in student satisfaction with the use of ML between public and private universities in the State of Kuwait?

Q2: Are there any differences in satisfaction based on students' gender, nationality (Kuwaiti and non-Kuwaiti), GPAs, and college attended for both public and private universities?

Q3: What are the factors, both technical and demographic, that best predict the level of satisfaction among students that use ML?

RESEARCH METHODOLOGY

The researchers followed a descriptive approach, which is appropriate for the nature of this study. To answer the research questions, a questionnaire was designed to gather information about students' satisfaction with using SPs in the learning process in both public and private universities in the State of Kuwait. The researchers requested 15 undergraduate volunteers from Kuwait University (KU) and 15 undergraduate volunteers from both the Gulf University for Science and Technology (GUST) and the American University of Kuwait (AUK) to distribute the questionnaire among students in all three universities and colleges of the current study. The questionnaire was divided into three sections. The first section asks 10 questions related to the student's background information. The second section of the survey asks students 23 questions about their satisfaction with using SPs in their learning process. The last section includes 10 more questions regarding learning and technology in general.

The analysis was performed using SPSS version 22 for Windows and utilizing Cronbach's alpha to test the internal consistency of the instrument. Further, ANOVA and t-tests were conducted to measure inferential statistics between independent and dependent variables. Finally, linear regression analysis was performed to understand the relationship between the variables. The researchers conducted a pilot study to test the questionnaire in a small portion of the population of KU, GUST and AUK students before collecting the actual data. To ensure the validity of the questionnaire, the researchers sent it to a group of arbitrators composed of faculty members to examine and determine the extent of its powers in achieving the goals of the research study.

SAMPLE OF THE STUDY

The original sample of this study was 1200 undergraduate students, who were randomly selected from among 38,200 undergraduate students from three universities. To ensure that every participant had a chance of selection for this study, the randomization was scheduled on two different days of lectures (Monday-Wednesday where the length of the lecture is 75 minutes and Sunday, Tuesday and Thursday where the length of the lecture is 50 minutes). The sample represented three universities: 31,000 students from KU, 5,100 students from GUST and 2,100 students from AUK. There were 614 female participants, representing 61% of the sample, and 398 male students. The representations of the study were reasonable because the number of female students is greater than the number of male students. The sample of the current study represented all colleges in the three universities (College of Law, College of Arts, College of Science, College of Medicine, College of Engineering and Petroleum, College of Allied Health Science, College of Education, College of Sharia and Islamic Studies, College of Business Administration, College of Pharmacy, College of Dentistry, College of Life Sciences, College of Social Sciences, College of Architecture, College of Computing Sciences and Engineering, and College of Public Health). The following section discusses the results of the present research study.

RESULTS AND DISCUSSION

The questionnaire was distributed among students at three public and private universities, for a total of 1200 undergraduate students. One hundred eighty-eight questionnaires were excluded due to redundant answers for all questions or because of failure to answer 95% of the questions. The majority (876) of the respondents were Kuwaiti nationals; 122 were non-Kuwaitis. Of the three universities, one was public (Kuwait University, n=550) and two were private (Gulf University for Science & Technology, n=174, and American University of Kuwait, n=289). Most of the students were 18 to 23 years of age (84%). Of the 1,012 students (398 male and 614 female) surveyed, 1,008 own smartphones; 70% (n=708) use their smartphone more than 4 hours daily, 24% (n=239) spend two to four hours daily, and only 6% (n=61) use it for an hour or less daily. Most students have access to the Internet using either 3G or 4G mobile-carrier networks, while others use campus Wi-Fi. Participants who use 3G represent

Table 1. Items Related to Smartphone Satisfaction

1	Using a smartphone helps me find new ways of learning at the university
2	I feel satisfied using a smartphone in my university's studies
3	A smartphone gives me flexibility to use it any time
4	I interact more with students when using a smartphone
5	Using a smartphone increases my interaction with my teacher in comparison with old methods
6	Using a smartphone increases my interaction with my university's studies in comparison with old methods
7	Learning through a smartphone is an effective interactive tool in the learning process
8	Using a smartphone in my university's studies saves me time
9	Using a smartphone in my university's studies saves me effort
10	I feel enthusiastic using a smartphone in my university's studies
11	I am satisfied with the content of the message when using the smartphone because it is concise and useful
12	Using a smartphone in my university's studies provides me the chance to get the information faster from other tools, including the computer
13	A smartphone helps me do my homework faster than other tools, including the computer
14	Using a smartphone in my university's studies increases my educational efficiency
15	Using a smartphone in my university's studies increases my educational achievement
16	Using a smartphone in my university's studies makes the learning process easier
17	I don't feel comfortable when using the smartphone in my university's studies
18	I can use a smartphone in my university's studies independently, without the need of others
19	I can use a smartphone in my university's studies in groups (like WhatsApp)
20	My instructor encourages me to use a smartphone in my classes
21	I recommend to my friends that they use a smartphone in their university's studies
22	I learn more when using a smartphone in my university's studies
23	I will take more courses in the future that depend on a smartphone

46.4% (n=470) of the sample, whereas those who use 4G totaled 21% (n=210). The remaining 27% use university Wi-Fi (n=270), and only a small number (4%) have a separate mobile Wi-Fi router (n=35) to connect to the Internet.

For the test of the students' satisfaction with using a smartphone, the reliability for the 23 items related to the smartphone satisfaction is α=.928, while the mean for the 23 items among the three universities was close, with M=3.83 and SD=.63383.

To answer **Q1**, a one-way between-subjects ANOVA was conducted to compare any significant differences in students' satisfaction between the three universities, and the result showed that there was no such difference at $p<.05$ [F (2, 1010) = .894, p = 0.409].

To answer **Q2**, dealing with the satisfaction among male and female students, a t-test showed that there was a significant difference based on gender $t(1009)=-3.449$, $p=.001$. Male students (M=3.75, SD=.65) were less likely to be satisfied than female students (M=3.90, SD=.61) when smartphones are used for educational purposes. The researchers believe that this outcome is due to cultural differences. Females tend to be more satisfied with ML than males because they perceive it as a means to freely express their thoughts and ideas and be more involved in discussion without any restrictions. Females look at ML as being a tool to exchange ideas. This result contradicts that of Tan, Ooi, Sim, and Phusavat (2012), which stated that the gender factor did not significantly affect the usage of mobile learning. However, this study is compatible with the results of Sarigöz (2016), where it was shown that female students had heightened perceptions of and were more satisfied with ML than male students. Another study conducted by (Alfailakawi, 2004) that tested the use of ML for Kuwait University students showed that female students were found to be more serious about using ML than male students.

For differences in students' satisfaction based on nationality, the t-test results showed that there was a significant indication that Kuwaiti students (M=3.85, SD=.62) are more satisfied than non-Kuwaiti students (M=3.68, SD=.72) in regard to satisfaction with ML $t(996)=2.96$, p = .003. The researchers believe that Non-Kuwaiti students may prefer and adopt a more traditional method of learning, while Kuwaitis tend to accept new methods of learning due to their wide exposure to technology and availability of sophisticated phones.

For satisfaction based on students' GPAs, a one-way between-subjects ANOVA analysis showed a significant difference [F (3, 971) = 3, p = .030] in this aspect. Students with GPAs higher than 3 out of 4 (M = 3.75, SD = .65) are more likely to be satisfied than those with GPAs between 2 and 2.49 (M = 3.91, SD = .57). This could be attributed to the fact that students with higher GPAs are more eager and motivated to learn new methods of learning to gain knowledge than those with lower GPAs. Similarly, a one-way between-subjects ANOVA analysis was also conducted to analyze the impact of colleges on student satisfaction. The results revealed that there were significant differences between colleges at the $p<.05$ level [F (12, 900) = 2.739, p = .001]. Pharmacy and Religious Studies colleges were less satisfied with ML, with m=3.6, whereas the colleges with the highest satisfaction were colleges

Table 2. M-learning Satisfaction Among Colleges

College	N	Subset for alpha = 0.05	
		1	2
Pharmacy	14	3.5911	
Religious Sharia	47	3.6181	3.6181
Others	82	3.6800	3.6800
Engineering and Petrol	67	3.6872	3.6872
Social	48	3.7167	3.7167
Science	92	3.8456	3.8456
Law	35	3.8527	3.8527
Business Administration	242	3.8733	3.8733
Medical	79	3.9048	3.9048
Arts	85	3.9236	3.9236
Medical Assistant	24	3.9634	3.9634
Life Sciences	22	3.9952	3.9952
Education	76		4.0445
Sig.		.137	.088

Table 3. Factors Affecting Students' Satisfaction

	Statements	N	Mean	Std. Deviation
1	Ease of carrying the smartphone helped me to use it in my studies	1010	4.295	0.78266
2	I have the skills to use the smartphone	1005	4.054	0.89992
3	Internet charges won't stop me from using a smartphone in my studies	1006	4.052	0.96264
4	Internet speed is sufficient to use a smartphone in my studies	1006	3.949	1.06064
5	I face problems when charging my smartphone on campus	1007	3.693	1.21217
6	Wi-Fi is available on all campuses	1004	3.653	1.28314
7	The small screen on the smartphone won't prevent me from using it in my studies	1009	3.599	1.15575
8	Wi-Fi signal is strong	1009	3.464	1.27434
9	I feel disappointed when I use a smartphone due to technical problems	1009	3.028	1.22686
10	Due to passwords, I face problems connecting to the Wi-Fi	1011	2.972	1.37128

of Education and Life Sciences, with m=4.0 (see **Table 2**). The researchers believe that religious people tend to be more cautious in using mobile learning and hesitate to try new ways of learning, such as adopting ML, as a part of their personal learning and development. The researchers also believe that students from the College of Sharia may not be exposed to heavy use of ML in their teaching style. Since the College of Sharia teaches Islamic and religion studies, the respondents are less likely to adopt ML. This finding supports the results of the study entitled "Kuwait University students use mobile learning," which concluded that students who majored in Islamic studies and in the College of Sharia were less satisfied with ML than were students in other colleges (Alfailakawi, 2004).

The ANOVA test revealed that there was a significant difference between groups' time spent on their smartphones and their satisfaction ([F (2, 1400) = 10.00, p = .001]. Students who spent more than 4 hours (M = 3.89; SD = .61) per day on their smartphones were more satisfied than those who spent one hour or less daily (M = 3.65; SD = .71) or those who spent between 2-4 hours daily (M = 3.71; SD = .66).

The mean and the standard deviation for the effect of technology on students' satisfaction showed that ease of carrying a smartphone (M = 4.29, SD = 0.78) is the leading factor for using ML, while students' skill came second (M = 4.05, SD = .899) (see **Table 3**).

To answer **Q3**, regarding the technical and demographical impact in predicting the level of satisfaction among students who use ML, a linear regression analysis was performed using satisfaction as the dependent variable. Various technical aspects were entered as the first block of independent variables, such as connection speed and cost, smartphone portability, smartphone technical problems, smartphone skills, smartphone screen size, battery charging on campus, Wi-Fi availability on campus, Wi-Fi signal power on campus, and password problems on campus. In the second block, other independent variables related to demographics were entered, such as gender, nationality, age, years in school, GPA, university, colleges, and time spent using a smartphone. The regression analysis revealed that the first set of the technology variables had significant impact (R^2 change = .428, F change (816, 10) = 61.130, p = .001). Of the technical variables, Internet speed (β = .095, p =.002), smartphone portability (β = .402, p =.001), smartphone skills (β = .196, p =.001), screen size (β = .134, p =.001), and password problems on campus (β = .134, p =.001) were the main predictors of smartphone ML satisfaction. Research in this field has classified these outcomes as external conditions or environmental factors that can facilitate satisfaction (Hassanein & Wang, 2010).

Table 4. Linear Regression Analysis of Predictors of Smartphone Satisfaction with M-Learning

Predictors	Regressions 1	Regressions 2
Internet speed	.095**	.095**
Portable	.402***	.391***
Internet cost	.012	.000
Technical problems	-.005	-.020
Skills	.196***	.202***
Screen size	.134***	.130***
Battery charging on campus	.036	.039
Wi-Fi availability on campus	.008	.021
Wi-Fi signal power	.031	.030
Password problems on campus	.134	.128***
Gender		.067*
Nationality		-.074**
Age		-.011
School year		.034
GPA		-.044
University		-.029
College		-.62*
Time spent using smartphone		.053*
R^2	.428	.450
Adjusted R^2	.421	.438
R^2 Change	.428	.022*

* p < .05, ** p < .01, *** p < .001

A second regression analysis including the second set of variables also revealed a significant impact level (R^2 change = .450, F change (808, 8) = 3.979, p = .001). All of the first set of variables, which were technical variables, including Internet speed (β = .095, p =.002), smartphone portability (β = .391, p =.001), smartphone skills (β = .202, p =.001), screen size (β = .130, p =.001), and password problems on campus (β = .128, p =.001), remained as predictors even after being controlled by the second set of predictors. Furthermore, the results showed that gender (β = .67, p = .018), nationality (β = -.074, p = .007), college (β = -.062, p = .025) and time spent using a smartphone (β = .053, p = .047) were additional predictors of smartphone satisfaction (see **Table 4**).

As a result, this study shows that Internet speed, smartphone portability, smartphone skills, screen size, password problems on campus, gender, nationality, type of college, and time spent using a smartphone are the main predictors of satisfaction with the use of smartphones in ML (see **Table 4**).

CONCLUSION AND FUTURE RECOMMENDATIONS

In conclusion, this study showed that students in public and private universities were satisfied using SPs in learning. The results revealed that female students were more satisfied with ML than male students. Moreover, Kuwaiti students were more satisfied than non-Kuwaitis. Further, students with high GPAs were more satisfied with ML than students with lower GPAs. In addition, students from Education and Life Science colleges were more satisfied with ML as compared to students from all other colleges, and the least satisfied students were from the colleges of Pharmacy and Religious Studies. It was found that students who spent more than four hours daily using SPs were more satisfied with ML than students who spent less time on their SPs. Finally, the study found that the factors that best predict level of satisfaction with smartphone-based ML were Internet speed, smartphone portability, smartphone skills, screen size, password problems on campus, gender, nationality, college type, and time spent using a smartphone. One implication of the current study based on constructivism theory is for educators to create lessons in which the students, not the teacher, are constructing meaning. Another implication is that male students should be motivated to use SP in their learning by creating a stimulating environment.

There are some limitations to the study that should be highlighted. The current study was limited to college students attending KU (which is a public university), and two private universities that are AUK and GUST. In addition, the study was conducted during spring semester of 2015/2016, and only undergraduate students from both gender were involved in the study.

For future research, we suggest expanding the current study to include graduate students in order to make the data more reliable. The researchers propose that policy makers should focus on and prepare appropriate infrastructure for ML in higher education institutes. Policy makers could officially set criteria and implement ML in higher education institutes in Kuwait for teaching and learning by taking the above factors into consideration.

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Evaluation of the Users of Edmodo Content Management System in Secondary Education

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ABSTRACT
This study aimed to investigate teachers' views about the effectiveness of users of Edmodo Content Management Systems in secondary education. Teachers from Near East College in Fall of 2016-2017 academic year participated in this study. Methodologically, qualitative research was carried out with open-ended interview questions prepared for the participants. Teachers' views were reached through the analysis of the data. The analysis results showed that the teachers already knew about Edmodo Content-Management System, but they were ineffective in practising it. Therefore, the findings reflected the need for educating the teachers in the system.

Keywords: Edmodo, Content Management System, imaginary learning environments

INTRODUCTION

Technology has always been an important aspect of education through its support of teacher and students in removing the barriers and limitations to learning development. Blumenfeld et al. (1991) argued that technology can sustain student motivation and support student learning and doing during the various phases of projects, can supplement and complement teachers' instructional and managerial roles, relieving teachers of some of the complexities of implementing projects.

The primary purpose of education today, is to raise individuals with skills to integrate IT into learning and teaching, access information easily, develop self-learning, be able to do research, and be creative. Karaman, Yıldırım, and Kaban (2008) stress that the use of Web. 2.0 tools in education helps more effective learning, has the responsibility for learning, collaborates through group-work and develops critical thinking skills. It also has advantages for the students, such as; sharing pictures or videos, on-line environments and private mailing. These advantages create tendency to use Web. 2.0 technologies in education (Karal & Karakoç, 2010). Besides the advantages, social networks have some disadvantages too, such as, improper advertising, internet perverts, cyber-bullying, which make teachers and families use the internet more carefully and due to such inconveniences, some schools tend to ban the use of social web sites (Harshman & Maguth, 2013) and develop environments that can only be used for education purposes.

We often face social learning environments, which are the essentials of education to raise creative individuals with the skills to access information easily and do research. According to Thongmag (2013), social learning environments facilitate educational interaction between teacher and student and among students. They also involve students in an active learning environment, facilitate collaboration in group projects, and provide easy sharing of course grades. The importance of on-line social web sites is the profile pages, on-line environments, private mailings, and their being open for everybody for interpretation (Rigby, 2008). For example the Stanford Mobile Inquiry-based Learning Environment (SMILE) combines a mobile-based question application for students with a management application for teachers. The classroom management software allows students to share, respond, and rate questions on criteria such as creativity or depth of analysis (Buckner & Kim, 2013).

Edmodo, for Jarc (2010), Kongchan (2008), Balasubramanian, Jaykumar¸and Fukey (2014), is a social web platform in which teachers can set an on-line classroom environment to easily interact with their students in safety and independent of time and place, and without costs. Developed for educational purposes in 2008, Edmodo offers free and secure software that supports varied education and teachers can create groups that students can join after

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Contribution of this paper to the literature

- This study has a vision to raise teacher awareness of the importance of the use of social learning environments in education.
- This research will contribute to the literature on the application of Edmodo platform.
- Teachers in the secondary education have a high perception of Edmodo Content Management System, but they lack the sufficient skills in applying it.

being invited by the teacher or by entering a group code (Végh, Nagy, Zsigmont, & Elbert, 2017). Through this platform, the teachers can share videos, pictures, office files, questionnaires, interactive quizzes, links and embed codes with their students (Doğan, 2012). Edmodo has provided great facilities in terms of education supported by Turkish language from 2013 onwards. The number of users of Edmodo is increasing day-by-day because it provides a wide range of collaboration among teachers.

The system's contribution to education;

- The use of technology contributes to learning
- The use of technology facilitates learning
- The use of technology raises awareness of its facilities it provides in education

In this study needs-analysis was done to specify the needs to define the effectiveness of the users of Edmodo Content Management System. In this respect, the following questions were asked;

1. What is the level of participant perception of Edmodo Content Management System application in language teaching?
2. What is the level of participant perception of_Edmodo Content Management System?
3. What is the level of participant perception of Edmodo application in general?

METHODOLOGY

Research Method

A qualitative research method was applied in this study. According to Yıldırım and Şimşek (2006), a qualitative research is an approach to understand the participant views and through induction to describe events and facts in their natural environments.

The Participants

Teachers from Near East College, in the 2016-2017 academic year, participated in this study.

Data Collection Tools

Three open-ended questions were prepared by the researcher as data collection tools. The questions were prepared after an overview of the literature to specify problems and expectations. The questionnaire were prepared in the light of the views by two experts in the field, one language expert, and one analyst. The questions were finalized in accordance with the feedbacks of the experts. While preparing the open-ended questionnaire utmost care was taken on the principles; to ask questions without multi-dimensions, questions being clear and understandable, and existence of alternative questions (Yıldırım & Şimşek, 2013).

Data Collection Procedure

In order to define the needs in_the effectiveness of the users of Edmodo Content Management System in language teaching in secondary education, unstructured interview forms were given to the participants.

Data Analysis

Out of 221 participants only 138 were evaluated within the scope of the research. The evaluation of the data was done in the light of the participant teachers' views.

FINDINGS

Participant views about Edmodo contribution to Language Teaching

The findings of this research indicate that many participants have positive views about Edmodo contribution to language teaching. P4 stated that, *"Students who have difficulties in expressing themselves in physical environments, can overcome such difficulties in social environments and this helps them develop their language skills"*. *"I totally agree that, connections and sharing all around the world will contribute to language teaching"*.

P78 supported this and added, "*I say it contributes. It helps teacher development and motivates students.*" P21 said "*I think it will be quite useful because several activities can be done in different languages"*. *"Due to the environment where there is interaction and students with different languages, they have the opportunity to exchange information*" explained by P59.

Some participants disagree with these positive views and stress that Edmodo does not contribute to language teaching.

P70 said that, *"Edmodo does not contribute to language teaching"*. A similar view was from P67, who said, "*Edmodo does not contribute much to language teaching"*. When the views of the participants with perception for the contribution of Edmodo use in language teaching analysed, positive contributions can be noted for language teaching because in an Edmodo environment the students are always in interaction and they get in contact with students from other countries.

Participant views about Edmodo Content Management System

From the data obtained in this research, it has been noted that many participants do not have sufficient knowledge about Edmodo Content Management System. P40 explained views saying, "*Both the teachers and students should be well informed about this program*". "*I do not have any suggestions because I rarely use it*" said P30. On the other hand, participants who knew about the Edmodo Content Management System raised positive views. P3 expressed views saying, "*Applications such as, Content Management System, sharing information through several systems, gathering exams and homework in a common page, and following performance are of great use*". "*It is quite a useful system because of its being a Content Management System and as long as it is practised, performance increases consequently*" added P21.

P28 raised views saying, *"I do not believe in any of such methods. Every kind of technology use, causes inattentiveness among students"*

P17 expressed dissatisfaction saying, "*Incorrect and useless information can be shared. Therefore, it is not very reliable*"

The participant teachers in this study did not have sufficient perception about Edmodo content system and thus many of them responded negatively which indicate that the use of technology in education was wrong for them.

Participant views about deficiencies in Edmodo applications

The study results indicate that, many of the participants expressed worries as them not being well informed about the discrepancies. As P33 stated, "*I do not use Edmodo Content Management System, so I have no idea about the discrepancies*". "*I do not know anything about Edmodo applications*" said P21. The reason for the lack of information about the system is assumed to have emerged from Edmodo's being a new application.

P17 explained saying, *"I do not use it so often so that I can notice what is wrong or right"*

P34 admitted saying, *"I have no idea because I do not use it"*

When the participants' perception of what is wrong and right about Edmodo use was considered, it is clear that they did not know much about Edmodo because they did not use it.

DISCUSSION

The findings indicated positive views in terms of the contribution of Edmodo to language teaching. Brady, Holcomb, and Smith (2010) points to the fact that educational social- web sites give the opportunity to teachers and students to use these webs for educational purposes. When literature is examined, it is noted that Edmodo is a new application and there are limited studies done on it. In the studies conducted, it is stated that Edmodo provides a safe and suitable environment serving educational activities (Çankaya, Durak, & Yunkul, 2014; Kongehan, 2008; Sanders, 2012). Echols and Tipton (2012) argue that, Edmodo is a social platform where information can be shared in safety, examinations can be given, homework can be assigned, grading can be followed, and questionnaires can be prepared. Research by Fardoun et al. (2012) support the use of social networking as an educational tool and discuss Edmodo as an educative online social network. The participant teachers had views indicating that students who have difficulties expressing themselves in physical environments, find it easier to do so in social environments where they improve their language skills. Ajjan and Hartshorn (2008) argue that such applications develop student writing skills, enhance learning, facilitate communication and raise motivation and involve students in the learning process. Another support came from Sırakaya (2014) who stressed that students who use Edmodo Content Management System can follow the courses outdoors and they do not lose interest in the courses. According to a study by Sanders (2012), this is in parallel with students' feeling of responsibility for their self-learning.

The findings in this research indicate that teachers lack sufficient information about Edmodo Content System and thus they need training in the application. In a similar research, the teachers and students who use Facebook as a social platform can understand the function of Edmodo and became able to use it in a minimum period of time (Shockney, 2013).

It was found out in the end of this research that some of the participant teachers did not have sufficient information about Edmodo Content System and are worried about not being able to use it. In a similar study, it is stressed that teachers can be members of Edmodo groups and contribute both to professional and personal development (Alemdağ, 2013).

CONCLUSION

It has been found out in this research that, teachers in the secondary education have a high perception of Edmodo Content Management System, but they lack the sufficient skills in applying it. The reason for this is related to the new application of the system in schools. Therefore, seminars and trainings should be organized to raise teacher awareness of the subject question.

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A Comparison of the Turkish and American Predoctoral Pediatric Education

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ABSTRACT

This study aimed to compare the Turkish (Karadeniz Technical University) and American (Boston University) predoctoral pediatric dental education. Given related curricula and first-hand observations at dental schools at Karadeniz Technical University and Boston University, documentary analysis was employed to emerge their similarities and differences. The authors, who matched the courses in both universities, found the following similarities between them: (a) class-hours; (b) subject matter and laboratory-based courses prior to pediatric clinic; (c) measurement and assessment methods; and (d) content knowledge. Moreover, their main differences appeared at the pediatric clinical treatment sessions, rotation (special needs and community clinics in Boston University; community clinics in Karadeniz Technical University), and subject-matter courses (e.g., *Child Abuse, Review Cases and Integrated Problem-Solving Exercise)*. This study sheds more light on collaborative works between dental schools and faculty of education. For example; the questions 'How are alternative strategies integrated into dental education?' and 'How are the subjects taught effectively?' should be inquired. The authors suggest to enhance international collaborations (e.g., student/faculty exchange programmes, distance education, monthly online meeting, and teleconferences) for achieving better dental education.

Keywords: curriculum, dental education, national context, pediatric dentistry, predoctoral pediatric education

INTRODUCTION

Advances in education, knowledge, and technology influence disease patterns and patient expectations. Hence, these rapid changes force medical and dental education to keep up with new trends/demands (Parsell, & Bligh, 1995). An evolution from the biology of oral diseases to the environmental and psychosocial determinants of oral health and disease has recently led to a substantial revision of curricular objectives in many dental schools (Khatami, MacEntee, & Loftus, 2008).

Nowadays, predoctoral dental education intends to train competent clinicians implementing effective patient care (i.e., restoration of calcified tooth structure). In a globalized world, dental schools follow similar research paradigms and trends in their curricula. Of course, these curricula indicate some differences in context, and culture (Bell, Barenie, & Myers, 1986). For example, home language legitimately affects dental education (i.e., Turkish and American English). Turkey and USA possess varied ethnical and cultural structures. The American dental education is very innovative whilst the Turkish one is generally adaptive to these innovations. Moreover, since the Turkish dental education is younger than the American one, clinical experiences/experiments are seen as an important topic. That is, the Turkish dental education views dental education as an inferior issue. Phrased differently, the Turkish dental education is very novice at discussing such topics as curriculum reform, educational research methods, innovative educational and assessment methodologies, and dental education around the world. Indeed, the American dental education has argued these issues since early 20th century. Given the foregoing

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Contribution of this paper to the literature

- Even though some of the related studies compared special patient care programmes/needs for developed and developing countries, none of them have explicitly concentrated on a comparison of predoctoral pediatric dentistry within national contexts (i.e., USA and Turkey). Therefore, this study is unique to fill in an important gap in the literature.
- Given features of the Turkish and American dental education (e.g., innovative and adaptive), the current study will illuminate pros and cons of their predoctoral pediatric dental education programmes.
- The current study helps dental educators to re-consider on future educational issues in dental education systems/curricula. In other words, the present study may, at hand, portray their SWOT analyses (especially, Karadeniz Technical University and Boston University).

issues, this current paper selected the Turkish and American predoctoral pediatric dental education programmes to compare them with each other. Therein, such a comparison may be helpful to design future educational topics in dental education systems/curricula (Ahmad, Razak, & Borromeo, 2014). Further, the current study may stimulate an interactive dialogue to empower predoctoral pediatric dental curriculum. Furthermore, this study at least indicates SWOT (Strengths-Weaknesses-Opportunities-Threats) analyses of predoctoral pediatric dental education in Karadeniz Technical University and Boston University.

American Dental Education System

Most dental schools in Northern America require applicants to have a bachelor's degree. Admission Department in each dental school review and assess applications via several criteria (e.g., academic background, recommendation letter and American Dental Admission Test (DAT) Scores). Then, applicants are called for personal interviews in regard to a list of priority order (ADEA, 2007; Wu, Zhang, Jiang, & Guo, 2010).

The American dental education typically consists of a four-year predoctoral education. Its first two years generally include basic science and preclinical instruction, whilst its last two years embrace clinical science instruction and patient care. After completing the predoctoral education, graduates may apply for a State Dental Board licensure (e.g., North East Regional Board of Dental Examiners Read—NERB--, and Western Regional Exam Board--WREB) (Ng, Glassman, & Crall, 2008). American dentists are also required to obtain *Continuing Education* credits every 2 years if they would like to renew their dental licenses. American dentists may get an additional postdoctoral education amongst nine recognized dental specialties, which may specify their practices/experiences. Specialty-trained dentists may also seek a voluntary board certification.

The American predoctoral dental education is provided by 66 universities (39 state universities; 27 private universities) (Douglass & Fein, 1995). The Commission on Dental Accreditation (CODA) accredits and standardizes all dental schools in these universities.

Turkish Dental Education System

After a high-stakes nation-wide examination, students submit a university list (maximally 30) to the Assessment, Selection and Placement Center (Ölçme, Seçme ve Yerleştirme Merkezi—ÖSYM) in regard to their scores (Çalik, 2014; Çalık, Ültay, Kolomuç, & Aytar, 2015). Then, the Assessment, Selection and Placement Center centrally places them into the universities in regard to their scores. That is, the high-stakes examination does not directly measure nor evaluate their knowledge of dentistry.

The Turkish dental education usually runs a five-year predoctoral education. Its first two years usually focus on 'biomedical sciences and preclinical laboratory skills' courses. The third year of the study contains 'clinical dental sciences' courses and dental observations in a dental hospital. The fourth and fifth years of the study require them to exclusively conduct patient care as interns. Their clinical experiences involve cooperation between dentistry students and mentors. Overall, the fifth-year of the Turkish dental education generally embraces direct clinic patient care (about 80%) and didactic instruction study (nearly 20%).

The Turkish dental education requires dentistry students to acquire adequate dental experiences in treating children properly. Undeniably, if students lack clinical competency at dental treatment for children, they may be reluctant to treat pediatric dentistry patients in their practices. Thus, their inabilities to treat pediatric dentistry patients increase specialist pediatric dentist's workloads (Bell, Barenie, & Myers, 1986; McKnightHanes, Myers, Russell, Barenie, Adair, Sams, & Krakowiak, 1996). This illuminates the significance of predoctoral dental education given the limited number of specialists.

There are currently 47 Turkish universities (37 states and 10 privates) including dental schools. All state universities are free of charge; but, private universities require students to meet their own tuitions. Currently, an increase in the popularity of the dentistry has affected the Higher Education Council's strategic plan on new dental schools. Turkey, as an EU candidate, has been conforming its educational reforms in regard to the Bologna Declaration intending to help students and staff obtain more reliable information about dental qualifications (Komabayashi, Ahn, Kim, & Oh, 2012; Şermet, Akgün, & Atamer-Şimşek, 2011). As a developing country, Turkey has also been revising its dental education based on the Bologna Declaration and developed countries' experiences (i.e., USA). For example, the Higher Education Council has just released on core dental education programme for a standardized dental education across the dental schools. This means that the developed countries dental programmes are a pivotal role in shaping the developing countries' ones.

Literature Review

Studies in dental education have focused on: (a) comparing special patient care programmes/needs (i.e., Saudi and U.S.; Malaysian and Australian) (Ahmad et al., 2014; Alkahtani, Stark, Loo, Wright, & Morgan, 2014; Schwenk, Stoeckel, & Rieken, 2017), (b) needs of community diversity (i.e., multicultural framework, minority/low-income) (Crall, Hewlett, & Friedman, 2009), (c) community-based dental education (Mascarenhas, 2011; Thikkurissy, Rowland, Bean, Kumar, Levings, & Casamassimo, 2008), (d) alternative educational strategies to enhance dentistry students' skills/abilities/competencies (Crall et al., 2009; Ng et al., 2008), (e) curriculum assessment and/or comparisons (Khatami et al., 2008; Komabayashi et al., 2012; Thikkurissy et al., 2008; Wu et al., 2010), and (f) subject-specific topics (i.e. Behavior Management Teaching, Atraumatic Restorative Treatment, experiences of clinical procedures, factors influencing dental students' specialty choice) in pediatric dentistry programme (Adair, Schafer, Rockman, & Waller, 2004; Kateeb et al., 2013; Klein, Storey, & Hanson, 2014; Seale, & Casamassimo, 2003; Shin et al., 2015). Even though some of the foregoing studies compared special patient care programmes/needs for developed and developing countries, none of them have explicitly concentrated on a comparison of predoctoral pediatric dentistry within national contexts (i.e., USA and Turkey). Therefore, this study is unique to fill in an important gap in the literature. Given features of the Turkish and American dental education (e.g., innovative and adaptive), the current study will illuminate pros and cons of the Turkish and American predoctoral pediatric dental education. Further, the current study may be seen as a first step to re-consider on future educational issues in dental education systems/curricula. On the other hand, the present study may, at hand, monitor their SWOT analyses (especially, Karadeniz Technical University and Boston University).

The Aim of the Study

This study aimed to compare the Turkish and American predoctoral pediatric dental education with each other (especially, Karadeniz Technical University and Boston University).

MATERIALS AND METHODS

The authors contacted the respective chairs of the departments of pediatric dentistry and used their personal and professional networks to obtain relevant curricula. A. Kuşgöz informally observed all educational procedures at Boston University Henry Goldman School of Dental Medicine as well as his active participation at Karadeniz Technical University Faculty of Dentistry. Then, he weekly negotiated co-authors (e.g., the chair of the department of pediatric dentistry and science educator) to decide further research steps.

Given related curricula and first-hand observations at both dental schools, documentary analysis was employed to emerge their similarities and differences (Çalık & Sözbilir, 2014). To make document analysis reliable and applicable, the authors separately matched the pediatric dentistry courses at Karadeniz Technical University with those at Boston University. Later, the authors and two independent researchers (one each from Boston University and Karadeniz Technical University) discussed matching and mismatching issues in these analyses. Such a peer review indicated a high agreement in the analyses. Any disagreement was solved through negotiation.

Because of variations in predoctoral pediatric education programmes suggested by the universities and limited access to their course contents and/or syllabus through their websites, the authors selected convenient sampling method to easily get all related documents. Hence, the authors attempted to at least yield a comparative view on the Turkish and American predoctoral pediatric dental education by handling only two specific cases from well-known dental schools (i.e., Karadeniz Technical University from Turkey and Boston University from the USA). Taking the number of dental schools and their diversities into consideration, this may be seen as a limitation of the current study.

RESULTS

An overview of the predoctoral pediatric dentistry education at Karadeniz Technical University and Boston University is presented in **Table 1**. Four themes for types of the pediatric dentistry courses appear: *subject matter of*

Table 1. An outline of predoctoral pediatric dental education in Boston University and Karadeniz Technical University

Learning method time	University	Academic year	Time (class-hours)	Assessment method	Sample Assessment Task/Question
Laboratory-based course	Boston University	2	12	Complementary Assessment (i.e. practical competency exam)	Please prepare and restore a pediatric model using stainless steel crown anterior composite and space maintainer
	Karadeniz Technical University	3	9		
Subject matter course	Boston University	3	48	Traditional assessment (e.g. short-answer question, matching items, multiple choice question)	What are avulsion treatment options in primary tooth?
	Karadeniz Technical University	3	21		
		4	28		
Clinical treatment sessions	Boston University	3,4	80	Complementary Assessment (i.e. practical competency exam, grading clinical work and structured—case studies--clinical examination)	Please diagnose, interpret and treat the case study of the patient
	Karadeniz Technical University	3	5	Complementary Assessment (i.e. clinical observation without patient care)	Please monitor clinical process and communication between dentist and patient
		4	80	Complementary Assessment (i.e. practical competency exam, grading clinical work and structured—case studies--clinical examination	Please directly conduct patient care in pediatric clinic
		5	80		
Rotation	Boston University (Community Clinics)	1	11	Complementary Assessment (i.e. field study)	Please write down how service learning influences your views of dental care.
	(Special Needs)	4	3	Complementary Assessment (i.e. clinical observation without patient care)	Please observe how to carry out patient care for special needs at Franciscan Hospital for Children
	Karadeniz Technical University (Community Clinics)	5	12	Complementary Assessment (i.e. field study)	Please address how to keep school children informed about oral mouth care.
Total	Boston University	1, 2, 3,4	154		
	Karadeniz Technical University	3,4,5	235		

knowledge (theoretical knowledge) that contains a lecturer-centered instruction or didactic instruction; *practical knowledge (laboratory-based course)* that involves hands-on experiments at the laboratory bench or the clinical simulation laboratory; *clinical treatment (practice)* that includes observation or direct patient care supervised by clinical instructors; and *rotation* that includes observation and community service.

Predoctoral pediatric dental education programme lasts at 154 class-hours at Boston University and 235 class-hours at Karadeniz Technical University. However, mean of class-hours in the entire academic years is 38.5 and 78.3 respectively. Predoctoral pediatric dental education programmes in both universities equally teach the laboratory and subject matter courses in practical and didactic formats. However, predoctoral pediatric dental education includes the clinical treatment sessions in Years 3-5 at Karadeniz Technical University and Years 3-4 at Boston University. Mean of class-hours in the clinical treatment sessions is 40 and 55 respectively. A total of the clinical treatment session at Karadeniz Technical University is higher than that of Boston University. As can be seen in **Table 1**, Boston University focuses on rotations in community clinics in Years 1 and 4 (year 1 is focused in service learning activities only, year 4 involves clinical work), and special needs in Year 4. Karadeniz Technical University concentrates on rotation in community clinics in Year 5, in which all students attend regular service-learning activities.

Assessment methods in both universities are also similar to each other. This means that both deploy traditional (e.g., paper-pencil questionnaire) and complementary (e.g. performance task, observation) assessment methods. As observed from **Table 1**, complementary assessment methods are common in predoctoral pediatric education programmes.

The content and class-hours of predoctoral pediatric subject matter courses are summarized in **Table 2**. The 'child abuse', 'review cases' and 'integrated problem solving' lectures at Boston University and 'operative dentistry'

Table 2. The content of each pediatric subject matter course in Boston University and Karadeniz Technical University in regard to year and time

Subject	Boston University		Karadeniz Technical University	
	Year	Time (class-hours)	Year	Time (class-hours)
Introduction to Pediatric Dentistry	3	2	3	3
Prevention: Fluoride, Oral Hygiene & Sealants.	3	2	3	2
Risk Assessment	3	2	3	1
Radiology for Pediatric Patients	3	2	4	2
Growth and Development	3	2	3	1
Oral Surgery for Pediatric Patients	3	2	4	3
Pharmacology & Therapeutics	3	2	4	2
Child Abuse	3	2	-	-
Infant Oral Health & ECC	3	2	3	2
Operative Dentistry	3	2	3	3
Pulp Therapy	3	2	3,4	5
Problems of Eruption	3	2	3	3
Space Maintenance	3	2	3,4	2
Dentistry for Developmentally Disabled	3	2	4	2
Behavior Management and Sedation	3	2	3	2
Dental Trauma	3	2	4	2
Access to Care	3	2	4	1
Dietary Counseling for Pediatric Patients	3	2	3,4	2
Oral Pathology for Pediatric Patients	3	2	4	4
Managing the Developing Dentition	3	2	3,4	4
Treatment Planning for Pediatric Patient	3	2	4	1
Periodontal Diseases in Children	3	2	4	2
Review Cases	3	2	-	-
Integrated Problem Solving(IPS) Exercise	3	2	-	-
Total		48		49

and 'pulp therapy' at Karadeniz Technical University are apparent as the remarkable differences between the Turkish and American predoctoral pediatric dental education.

DISCUSSION

As seen in **Table 1**, class-hours of laboratory-based and subject matter courses are almost the same for the Turkish and American predoctoral pediatric dental education. This may come from pre-requests and/or requirements of predoctoral pediatric dental education. Hence, the dentistry students are expected to get prepared for pediatric clinic. Phrased differently, prior to providing patience care at the pediatric clinic, they underpin their knowledge of subject matter and laboratory-based courses.

Even though clinical instruction in pediatric dentistry seems broadly similar in many American dental schools and elsewhere (Klein et al., 2014; McKnightHanes et al., 1996; Seale, & Casamassimo, 2003; Wu et al., 2010), the main difference between the Turkish and American predoctoral pediatric dental education is the pediatric clinical treatment sessions (see **Table 1**). This may stem from duration differences of the American (e.g., a four-year dental education) and Turkish dental education (e.g., a five-year dental education). Further, pediatric clinical treatments are covered in Years 3-5 for the Turkish dental students and Years 3-4 for the American ones. The limited pediatric clinical treatment in the USA may come from an inadequate pediatric patient pool threating predoctoral students' patient care competencies (Casamassimo, & Seale, 2015; Seale, & Casamassimo, 2003).

A principal difference for special needs under rotation (see **Table 1**) may result from a lack of infrastructure at Karadeniz Technical University. In fact, Boston University collaboratively deals this issue with Franciscan Hospital for Children. Karadeniz Technical University have such topics as the dental management of children with intellectual or medical disabilities; but they have no opportunity to practically implement patient care for this population. Since they attend poor practical training in special need patients (Holder, Waldman, & Hood, 2009), they generally direct these cases to specialty clinics.

Although their years of the study are different (i.e., Year 1 in Boston University and Year 5 in Karadeniz Technical University), dental students at both universities attend community clinics, as part of their service learning education in public schools. Hence, they have an opportunity to teach oral health to children in a classroom environment. This may stem from the idea 'Preventive dentistry plays a significant role in school-based oral health education'. In a similar vein, these regular service-learning activities act as a catalyst to stimulate the sustainability of pediatric dental education (Haleem et al., 2016).

Because dental education incorporates both laboratory-based and clinical treatment sessions, the assessment methods in the Turkish and American predoctoral pediatric education are very similar to each another. Indeed, these sessions mainly concentrate on learning process within complementary assessment rather than learning outcome within traditional assessment. Further, diverse complementary assessment methods may result from features of predoctoral pediatric dental education. As a matter of fact, laboratory-based courses involve practical competency exam, whilst clinical treatment sessions incorporate clinical observation/examination (see **Table 1**). Interestingly, the fact that subject matter courses refer to traditional assessment may come from their theoretical frameworks and/or lecturer-based instruction.

As seen in **Table 2**, most subjects in the Turkish (Karadeniz Technical University) and American (Boston University) predoctoral pediatric dental education overlap each other; but, 'Child Abuse', 'Review Cases' and 'Integrated Problem Solving (IPS) Exercise' lectures are only available at Boston University. Boston University places special emphasis on evidence-based treatment approaches. The rationale behind "Review Cases and IPS" may stem from the need to offer integrated evidence-based approaches to treatment covering different topics. The IPS sessions ask dental students to review current literature and discuss treatment plan options that emerge in the reasoning behind certain clinical decisions in Pediatric Dentistry. The courses 'Operative Dentistry' and 'Pulp Therapy' seem more intensive in the Turkish (Karadeniz Technical University) predoctoral pediatric dental education than the American (Boston University) one. This may stem from a higher amount of clinical treatment sessions and/or fifth-year of the Turkish dental education (Karadeniz Technical University). Another possible reason is cross-training of these subjects in other courses offered at the American predoctoral dental education (Boston University). For example, trauma and pulp therapy are also offered in the Endodontic curriculum. Other possible explanations may be due to differences in patient pool, disease epidemiology, trends in childhood and insurance coverage between the two countries. In Turkey, dental treatment coverage is financially met by the Turkish government. In the United States, the pediatric population has reduced untreated caries rates as compared with Turkey.

CONCLUSION AND RECOMMENDATIONS

To sum up, the principal similarities between the Turkish (Karadeniz Technical University) and American (Boston University) predoctoral pediatric dental education are as follows: (a) class-hours; (b) subject matter and laboratory-based courses prior to pediatric clinic, (c) measurement and assessment methods, (d) content knowledge. Their main differences appear at; (a) the number of pediatric clinical treatment sessions; (b) rotation (special needs and community clinics in Boston University; community clinics in Karadeniz Technical University), and (c) some subject-matter courses (e.g., *Child Abuse, Review Cases and Integrated Problem Solving (IPS) Exercise)*.

This study sheds more light on collaborative works between dental schools and faculty of education. For example; the questions 'How are alternative strategies integrated into dental education?' and 'How are the subjects taught effectively?' should be inquired. Given pros (e.g., Special needs in Boston University; Clinical treatments in Karadeniz Technical University) and cons (e.g., Child abuse subject in Karadeniz Technical University) of the Turkish and American dental education programmes, international collaborations should be enhanced to achieve better dental education via student/faculty exchange programmes, distance education, monthly online meeting, and teleconferences. Also, the current study is supposed to be extended with an undeveloped country. Given the number and programme diversity of dental schools in the USA and Turkey, the current study only focused on two well-known dental schools (i.e., Boston University and Karadeniz Technical University). Future studies ought to reflect on their own efforts of predoctoral pediatric dentistry using programme diversity, learning outcomes, contexts and other variables.

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A Novel Method Based on Induced Aggregation Operator for Classroom Teaching Quality Evaluation with Probabilistic and Pythagorean Fuzzy Information

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ABSTRACT

The purpose of this study is to develop a novel method based on induced aggregation operator to evaluate classroom teaching quality with probabilistic and Pythagorean fuzzy (PF) information. Inspired by the induced ordered weighted averaging (IOWA) operator, a PF aggregation operator called the PF induced probabilistic ordered weighted average (PFIPOWA) operator is developed. This operator uses probabilities and order-induced variables in the same formulas to aggregate PF information. Some of key features and special cases of the PFIPOWA operator are also investigated. Finally, the practicality of the developed operator is tested by using realistic classroom teaching quality evaluation problems. Hopefully, the research of this paper is of great significance to the evaluation of classroom teaching quality problems.

Keywords: Pythagorean fuzzy set, induced aggregation operator, probabilistic information, classroom teaching quality evaluation, multi-attribute decision making

INTRODUCTION

The evaluation of classroom teaching quality (CTQ) is an important activity in higher education and is of crucial importance to ensure the improvement of teaching quality in colleges and universities, thus the continuous improvement of teaching is the central task for education. There is no doubt that the scientific and effective method of CTQ evaluation plays a significant role in stimulating teachers' enthusiasm and enhance their teaching ability. Generally, teachers are assessed by professional people with respect to different attributes in the process of CTQ evaluation, which can be considered as a multi-attribute decision making (MADM) problem (Yu, 2013; Yu & Lai, 2011; Yu et al., 2009; Zhang et al., 2017b). The evaluation of CTQ is a very complicated decision process because of uncertain and fuzzy information involved. Pythagorean fuzzy set (PFS) (Yager, 2014), characterized by a membership degree (μ) and a non-membership degree (v), has recently been introduced to deal with the complex uncertainty, which is satisfying the restrictions of $\mu^2 + v^2 \leq 1$. This extended constraint condition makes PFS stronger than traditional intuitionistic fuzzy set (IFS) (Atanassov, 1986) because it can describe imprecise and ambiguous information, whereas the latter cannot.

In the literature, Yager (2014) further developed a new and useful decision method to manage the MADM problems under PF environment after some aggregation operations of PFS were defined. Chen (2018) gave a remoteness index-based methods to measure distance between PF sets. Zhang and Xu (2014) extended the traditional TOPSIS method to handle the PF MADM problems. Zhang (2016) developed a novel ranking the PF number based on the closeness index. Peng and Yang (2015) introduced a superiority- inferiority ordering method to solve PF MADM. Peng and Yang (2016) presented a method based on Choquet integral for PF MADM problems. Zeng et al. (2016a) proposed a hybrid distance measure of the PFSs and studied its application in MADM problems. Zeng (2017) presented a PF MADM method based on probabilistic approach. Based on prospect and regret theory,

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Contribution of this paper to the literature

- The developed new Pythagorean fuzzy aggregation operator is able to consider both the probabilistic information and complex attitudinal characters of decision makers.
- A new MADM model based on the developed operators are presented under Pythagorean fuzzy situation.
- A novel evaluation framework for Classroom teaching quality evaluation is given. This may be play a significant role in the improvement of classroom teaching quality evaluation.

Peng and Dai (2017) developed a PF stochastic decision making model. Wei (2017) developed some PF interaction aggregation operators and studied their application to MADM problem.

Considering that PFS is able to describe inaccurate and fuzzy information better than IFS and has been broadly applied in practical MADM problems, this paper will develop a new model to manage effectively PF MADM problems. It is based on the PFIPOWA operator, which unifies the probabilistic information with the order-induced variables in the same expression to aggregate the PF information. Therefore, it can manage probabilistic information and represent complex attitudinal characters by using order-induced variables. The major advantage and particular cases of the proposed operator are investigated. Finally, the practicality of the developed operator is tested by using actual CTQ evaluation problems, which is similar to Shieh and Yu (2016).

The remainder of this article is organized as follows. Section 2 reviews some basic preparations. Section 3 presents the PFIPOWA operator and studies some basic properties and special cases. Section 4 discusses the applicability of the PFIPOWA operator with a MADM example concerning CTQ evaluation. Insection 5 we summarize the main results of the paper.

PRELIMINARIES

We will briefly review basic concepts of PFS in this section. Meanwhile, the Pythagorean fuzzy OWA (PFOWA), the IOWA and the probabilistic OWA operator are further presented.

Pythagorean Fuzzy Set

Definition 1. Let a set $Y = \{y_1, y_2, \dots, y_n\}$ be fixed, a PFS P is defined as:

$$P = \{\langle y, P(\mu_P(y), v_P(y))\rangle | y \in Y\} \tag{1}$$

The numbers $\mu_P(y)$ represents the membership degree, while $v_P(y)$ non-membership degree of the element y to P, $0 \le (\mu_P(y))^2 + (v_P(y))^2 \le 1$, for all $y \in Y$. $\pi_P(y) = \sqrt{1-(\mu_P(y))^2-(v_P(y))^2}$ represents the degree of indeterminacy of y to P. For convenience, we call the pair $P(\mu_P(y), v_P(y))$ Pythagorean fuzzy number (PFN), denoted as $\beta = P(\mu_\beta, v_\beta)$, where $\mu_\beta \in [0,1]$, $v_\beta \in [0,1]$ and $(\mu_\beta)^2 + (v_\beta)^2 \le 1$.

Consider any three Pythagorean fuzzy numbers (PFNs) $\beta = P(\mu_\beta, v_\beta), \beta_1 = P(\mu_{\beta_1}, v_{\beta_1})$ and $\beta_2 = P(\mu_{\beta_2}, v_{\beta_2})$, some operational rules are defined as follows (Yager, 2014):

(1) $\beta_1 \oplus \beta_2 = P\left(\sqrt{\mu_{\beta_1}^2 + \mu_{\beta_2}^2 - \mu_{\beta_1}^2 \cdot \mu_{\beta_2}^2}, v_{\beta_1} \cdot v_{\beta_2}\right)$;

(2) $\beta_1 \otimes \beta_2 = P\left(\mu_{\beta_1} \cdot \mu_{\beta_2}, \sqrt{v_{\beta_1}^2 + v_{\beta_2}^2 - v_{\beta_1}^2 \cdot v_{\beta_2}^2}\right)$;

(3) $\lambda\beta = P\left(1-(1-\mu_\beta^2)^\lambda, (v_\beta)^\lambda\right), \quad \lambda > 0$;

(4) $\beta^\lambda = P\left((\mu_\beta)^\lambda, 1-(1-v_\beta^2)^\lambda\right), \quad \lambda > 0$.

Definition 2 (Zhang and Xu, 2014). For two PFNs $\beta_1 = P(\mu_{\beta_1}, v_{\beta_1})$ and $\beta_2 = P(\mu_{\beta_2}, v_{\beta_2})$, $\beta_1 \ge \beta_2$ if and only if $\mu_{\beta_1} \ge \mu_{\beta_2}$ and $v_{\beta_1} \le v_{\beta_2}$.

Definition 3 (Zhang and Xu, 2014).For a PFN$\beta = (\mu_\beta, v_\beta), S(\beta) = (\mu_\beta)^2 - (v_\beta)^2$ and $H(\beta) = (\mu_\beta)^2 + (v_\beta)^2$ are named the score function and accuracy function of α, respectively. For two PFNs $\beta_1 = (\mu_{\beta_1}, v_{\beta_1})$ and $\beta_2 = (\mu_{\beta_2}, v_{\beta_2})$, if $S(\beta_1) > S(\beta_2)$, then $\beta_1 > \beta_2$; if $S(\beta_1) = S(\beta_2)$, then

(1) If $H(\beta_1) < H(\beta_2)$, then $\beta_1 < \beta_2$;

(2) If $H(\beta_1) > H(\beta_2)$, then $\beta_1 > \beta_2$.

Pythagorean Fuzzy OWA Operator

To aggregate PFNs, based on the basic operational laws of PFNs, Zhang (2016) defined the PF ordered weighted averaging (PFOWA) operator as follows.

Definition 4. Let $\beta_j = P\left(\mu_{\beta_j}, v_{\beta_j}\right)$ $(j = 1,\ldots,n)$ be a set of PFNs, the PFOWA operator associated weighting $W = (w_1,\ldots,w_n)$ with $\sum_{j=1}^{n} w_j = 1$is defined by the following formulas:

$$PFOWA(\beta_1,\beta_2,\ldots,\beta_n) = \sum_{j=1}^{n} w_j \gamma_j = P\left(\sqrt{1-\prod_{j=1}^{n}(1-\mu_{r_j}^2)^{w_j}}, \prod_{j=1}^{n} v_{r_j}^2\right) \tag{2}$$

where γ_j is the jth largest of the β_i. Note that if γ_j and β_i have same ordered position, then the PFOWA operator becomes to the PF weighted averaging (PFWA).

The IOWA Operator

The IOWA operator (Yager & Filev, 1999) is a widely used operator in decision making problems. Until now, it has studied and extended by thousands of publications in various kinds of journals and conferences (Merigó & Gil-Lafuente, 2013; Xia et al., 2011; Xian et al., 2016; Yu, 2014; Zeng et al., 2017; Zhang et al., 2014; Zhou & Chen, 2013).

Definition 5. An IOWA operator of dimension n is a mapping IOWA: $R^n \times R^n \rightarrow R$ that has an associated weighting $V = (v_1,\ldots,v_n)$ with $\sum_{j=1}^{n} v_j = 1$ such that:

$$IOWA(\langle u_1,b_1\rangle,\langle u_2,b_2\rangle,\ldots,\langle u_n,b_n\rangle) = \sum_{j=1}^{n} v_j a_j \tag{3}$$

where $(a_1,a_2,\ldots,a_n)$ is the reordered version of $(b_1,b_2,\ldots,b_n)$ induced by $(u_1,u_2,\ldots,u_n)$.

The Probabilistic OWA Operator

The probabilistic OWA (POWA) operator (Merigó, 2010, 2011a) is a new aggregation method that combines the main advantages of the probability and the OWA operator (Yager, 1988).

Definition 6. A POWA operator of dimension n is a mapping POWA: $R^n \rightarrow R$ that has an associated weighting vector V with $v_j \in [0,1]$ and $\sum_{j=1}^{n} v_j = 1$, such that

$$POWA(b_1,b_2,\ldots,b_n) = \sum_{j=1}^{n} \hat{p}_j a_j \tag{4}$$

where a_j is the jth largest of the b_i, which has an associated probability p_i satisfying $0 \le p_i \le 1$ and $\sum_{i=1}^{n} p_i = 1$, $\hat{p}_j = \lambda v_j + (1-\lambda)p_j$ with $\beta \in [0,1]$ and p_j is the probability p_i ordered based on a_j, that is, according to the jth largest of the b_i. Especially, when $\lambda = 0$, we get the probabilistic average, and if $\lambda = 1$, the OWA operator.

THE PYTHAGOREAN FUZZY INDUCED PROBABILISTIC OWA OPERATOR

The PFIPOWA Operator

The PFIPOWA operator is a new aggregation model that integrates the IOWA operator and the POWA operator in the same formula. Therefore, the PFIPOWA is very relevant because it provides more flexibility to consider the importance of each concept has in the analysis. It is defined as follows.

Definition 7.A PFIPOWA operator of dimension n is a mapping PFIPOWA: $\Omega^n \times R^n \rightarrow \Omega$ that has an associated weights V with $v_j \in [0,1]$ and $\sum_{j=1}^{n} v_j = 1$ such that:

$$PFIPOWA(\langle u_1,\beta_1\rangle,\langle u_2,\beta_2\rangle,\ldots,\langle u_n,\beta_n\rangle) = \sum_{j=1}^{n} \widehat{w}_j \gamma_j \tag{5}$$

where γ_j is the recorded value of β_i induced by u_i, each PFN β_i has an associated probability p_i satisfying $0 \le p_i \le 1$ and $\sum_{i=1}^{n} p_i = 1$, $\widehat{w}_j = \lambda v_j + (1-\lambda)p_j$ with $\lambda \in [0,1]$ and p_j is the ordered value of p_i related to γ_j, that is, based on the j the largest of the β_i.

In the next example, we present a numerical example to show aggregation process of the PFIPOWA operator.

Example 1. Let $\beta = (P(0.9,0.3), P(0.6,0.5), P(0.7,0.4), P(0.8,0.2))$ be the aggregated arguments with the order-induced variables $U = (7,4,1,9)$, the weights $v_1 = v_2 = 0.2, v_3 = v_4 = 0.3$, and the probabilistic weights vector be

$P = (0.2,0.4,0.1,0.3)$. It is assumed that the probability information has an importance of 70%, while the degree of the weight vector is 30%. Then we should calculate the new weighting vector if we use the Eq. (5):

$\hat{w}_1 = 0.3 \times 0.2 + 0.7 \times 0.1 = 0.13$, $\hat{w}_2 = 0.3 \times 0.2 + 0.7 \times 0.2 = 0.2$,

$\hat{w}_3 = 0.3 \times 0.3 + 0.7 \times 0.3 = 0.3$, $\hat{w}_4 = 0.3 \times 0.3 + 0.7 \times 0.4 = 0.37$.

And then, based on the PFIPOWA operator, we have:

$$PFIPOWA(\langle u_1, \beta_1 \rangle, \ldots, \langle u_4, \beta_4 \rangle) = P(0.76,0.37)$$

If the weighting vector of the OWA and probabilities are not standardized, i.e., $\hat{V} = \sum_{j=1}^{n} \hat{v}_j \neq 1$, then the PFIPOWA operator should be formed as:

$$PFIPOWA(\langle u_1, \beta_1 \rangle, \langle u_2, \beta_2 \rangle, \ldots, \langle u_n, \beta_n \rangle) = \frac{1}{\hat{V}} \sum_{j=1}^{n} \hat{v}_j \gamma_j \tag{6}$$

Main Properties of the PFIPOWA Operator

The IFPIOWA operator has the similar properties as the IOWA and POWA operators, that is, it satisfies monotonicity, commutativity, idempotency and boundedness. Suppose f is the PFIPOWA operator, these properties can be expressed by the Theorem1 to Theorem 4.

Theorem 1 (Monotonicoty). If $\beta_j \geq \beta'_j$ for all j, then:

$$PFIPOWA(\langle u_1, \beta_1 \rangle, \ldots, \langle u_n, \beta_n \rangle) \geq PFIPOWA(\langle u_1, \beta'_1 \rangle, \ldots, \langle u_n, \beta'_n \rangle) \tag{7}$$

Theorem 2 (Commutativity). If $(\langle u'_1, \beta'_1 \rangle, \ldots, \langle u'_n, \beta'_n \rangle)$ is a permutation of the aggregated pair $(\langle u_1, \beta_1 \rangle, \ldots, \langle u_n, \beta_n \rangle)$, then

$$PFIPOWA(\langle u_1, \beta_1 \rangle, \ldots, \langle u_n, \beta_n \rangle) = PFIPOWA(\langle u'_1, \beta'_1 \rangle, \ldots, \langle u'_n, \beta'_n \rangle) \tag{8}$$

Theorem 3 (Idempotency). If $\beta_j = \beta$ for all j, then

$$f(\langle u_1, \beta_1 \rangle, \ldots, \langle u_n, \beta_n \rangle) = \beta \tag{9}$$

Theorem 4 (Boundedness). The PFIPOWA operator is bounded by the max and min values, i.e.,

$$min\{\beta_j\} \leq f(\langle u_1, \beta_1 \rangle, \ldots, \langle u_n, \beta_n \rangle) \leq max\{\beta_j\} \tag{10}$$

Note that the proofs of these theorems are straightforward and thus omitted for sake of brevity. Moreover, Given the PFIPOWA operator relies on probabilistic property, one can prove that it is a semi boundary condition:

$$\lambda min\{\beta_i\} + (1-\lambda) \times \sum_{i=1}^{n} p_i \beta_i \leq f(\langle u_1, \beta_1 \rangle, \ldots, \langle u_n, \beta_n \rangle) \leq max\{\beta_i\} + (1-\lambda) \times \sum_{i=1}^{n} p_i \beta_i \tag{11}$$

Families of PFIPOWA Operator

A series of particular aggregation operators can be obtained by analyzing the coefficient λ, the weights V and the order-induced value U in the PFIPOWA operator. Some interesting special cases (among others) can be identified:

Remark 1. Basically, if $\lambda = 0$, i.e., the relative importance of the WA approach to zero, we get the Pythagorean fuzzy probabilistic aggregation (PFPA). Conversely, if $\lambda = 1$, PF the induced OWA (PFIOWA) operator. Furthermore, if $\gamma = 1$ and the ordering of order-inducing variables coincides with the input arguments, the PFOWA operator is obtained.

Remark 2. Another group of important cases are the maximum PFPA (Max-PFPA), the minimum PFPA (Min-PFPA) and the step-PFIPOWA.

- The Max-PFPA is found when $v = (1,0,\ldots,0)$.
- The minimum PFPA is found when $v = (0,\ldots,0,1)$.
- The general step-PFIPOWA is formed when $v_k = 1$ and $v_j = 0$, for all $j \neq k$.

Remark 3. We assign $v_{(n+1)/2} = 1$ when n is odd, and $v_j = 0$ for all others, then we get the median-PFIPOWA. If n is even, then we assign $v_{n/2} = v_{(n/2)+1} = 0.5$.

Remark 4. Numerous other types can be analyzed in accordance with methods widely used in the OWA-based literature (Aggarwal, 2015; Merigó, 2011b; Xian et al., 2016; Zeng et al., 2016b; Zhang et al., 2017a).

Table 1. PF evaluation matrix

	C_1	C_2	C_3	C_4	C_5
A_1	P (0.8,0.4)	P (0.9,0.3)	P (0.6,0.7)	P (0.8,0.3)	P (0.6,0.5)
A_2	P (0.5,0.7)	P (0.9,0.2)	P (0.8,0.5)	P (0.6,0.3)	P (0.6,0.6)
A_3	P (0.6,0.3)	P (0.3,0.7)	P (0.7,0.4)	P (0.4,0.6)	P (0.8,0.4)
A_4	P (0.6,0.5)	P (0.7,0.5)	P (0.7,0.5)	P (0.6,0.4)	P (0.7,0.3)
A_5	P (0.7,0.5)	P (0.6,0.4)	P (0.9,0.3)	P (0.8,0.6)	P (0.7,0.1)

Table 2. Aggregated results of PFIPOWA operator

	PFIPOWA	Scores	Ranking
A_1	P (0.783,0.454)	0.448	2
A_2	P (0.722,0.424)	0.341	3
A_3	(0.613,0.451)	0.172	5
A_4	P (0.660,0.432)	0.249	4
A_5	P (0.755,0.333)	0.460	1

Extension of the PFPIOWA Operator

A further extensions of the PFPIOWA operator can be studied by employing the generalized means (Merigó & Gil-Lafuente, 2013; Zeng et al., 2016b) which is very useful for representing a complete picture when we want to consider more choices. The result is generalized PFPIOWA (GPFPIOWA) operator:

Definition 8. A GPFIPOWA operator of dimension n is a mapping GPFIPOWA:$\Omega^n \times R^n \rightarrow \Omega$ that has an associated weighs V with $v_j \in [0,1]$ and $\sum_{j=1}^{n} v_j = 1$ such that:

$$GPFIPOWA(\langle u_1, \beta_1\rangle, \langle u_2, \beta_2\rangle, \ldots, \langle u_n, \beta_n\rangle) = \left(\sum_{j=1}^{n} \widehat{w}_j\, \gamma_j^t\right)^{1/t} \tag{12}$$

where $\widehat{w}_j = \lambda v_j + (1-\lambda)p_j$ with $\lambda \in [0,1]$, t is parameter that satisfies $t \in (-\infty, +\infty) - \{0\}$. Generally, we can the families of GPFIPOWA by studying the coefficient λ, the weight V, the order-induced value U and the parameter t. More specially,

- If $t = 1$, then the GPFIPOWA reduces to the PFPIOWA operator, thus all PFPIOWA's particular cases can be seen as GPFPIOWA's special cases.
- If $t = 2$, we get the PF induced probabilistic quadratic ordered weighted averaging (PFIPQOWA) operator
- If $t = -1$, the PF induced probabilistic harmonic ordered weighted averaging (PFIPHOWA) operator is obtained.
- Etc.

CLASSROOM TEACHING QUALITY EVALUATION WITH THE PFIPOWA OPERATOR

Next, a numerical example concerning CTQ evaluation (adapted Zhang et al., 2017b) is given to illustrate the use of the PFIPOWA in a MADM problem. Assume a university desires to enhance classroom teaching quality by way of teaching match. Several professor and students are invited to evaluate five teachers $\{A_1, A_2, A_3, A_4, A_5\}$ from the following five attributes: teaching attitude (C_1); teaching ability (C_2); teaching content (C_3), teaching method (C_4) and teaching effect (C_5).

Due to the uncertainty associated with the analysis of the phenomenon, the evaluation values of various alternatives with respect to attribute given by the professor are represented by PFNs, showed in **Table 1**.

In this problem, the order-inducing variables is assumed $U = (10,12,8,9,7)$, which presents complex attitudinal character in the decision process. We assume that $\lambda = 0.4$, $P = (0.3,0.3,0.1,0.2,0.1)$ and $V = (0.1,0.2,0.2,0.2,0.3)$. By exploiting the above information, the PFIPOWA operator can be used to aggregate the evaluated values and to select the best desired alternative. The results are shown in **Table 2**.

From the **Table 2**, we can get the optimal ranking order of these five companies: $A_5 \succ A_1 \succ A_2 \succ A_4 \succ A_3$, obviously the most desirable alternative is A_5. Moreover, it is interesting to examine the validation of results by using some special cases of the PFPIOWA and the GPFIPOWA operators. In this case, we will consider the Max-PFPA, Min-PFPA, PFWA, PFOWA, PFIOWA, PFIPOWQA and the PFIPOWHA. The ranking of results by the different cases are shown in **Table 3**.

Table 3. Ranking of the potential teachers

Special Cases	Ordering
Max-PFPA	$A_2 \succ A_3 \succ A_5 \succ A_4 \succ A_1$
Min-PFPA	$A_5 \succ A_2 \succ A_1 \succ A_3 \succ A_4$
PFWA	$A_1 \succ A_5 \succ A_2 \succ A_3 \succ A_4$
PFOWA	$A_1 \succ A_2 \succ A_3 \succ A_5 \succ A_4$
PFIOWA	$A_5 \succ A_2 \succ A_1 \succ A_3 \succ A_4$
PFIPOWQA	$A_5 \succ A_2 \succ A_1 \succ A_3 \succ A_4$
PFIPOWHA	$A_5 \succ A_2 \succ A_1 \succ A_4 \succ A_3$

As we can see, the ranking of the alternatives may be different depending on the particular cases used. Therefore, this approach is quiet flexible because it enables the decision maker(s) to have more options to select aggregation schemes. Thus, the decision maker will choose the one that is most suitable for his or her beliefs or interests.

CONCLUSIONS

In this paper, a new PF aggregation operator that uses the principal features of the probability, the order-induced variables and uncertain information in form of PFNs is developed. Some of its main properties are analyzed. In addition, various particular cases of the PFIPOWA operator including the PFWA and the PFOWA operator are investigated. Moreover, the application of the new approach to MADM problem concerning CTQ evaluation is presented. We have seen that the PFIPOWA is very capable because we can assess the progress of decision making progress taking into account the probabilities and the attitudinal character of decision makers. Thus, this method is very flexible because by assigning different parameter values to the operator, more opportunities can be given to choose a particular situation. Therefore, it enriches the existing method of aggregating Pythagorean fuzzy information.

In future studies, we hope to further expand this operator by using distance measures and other new characteristics. The application of the presented model may be explored in other areas, such as engineering, economics and material recognition.

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A Study of Knowledge Management and Organizational Learning under Environmental Education

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ABSTRACT

Under the globalized and fiercely competitive external environment, manufacturers have to enhance the organizational learning capability to cope with the challenge of Environmental Education. In addition to developing and cultivating the knowledge management capability, manufacturers have to co-develop, share, and spread relevant knowledge among different bodies in the external network. The theoretical relationship among manufacturers' knowledge management in global manufacturing network, knowledge management in supply chain network, and organizational learning capability is proposed in this study, and the moderation effect of Environmental Education is further discussed. Based on 2013 International Manufacturing Strategy Survey VI (IMSS VI) of 463 manufacturers in 22 countries and regions. The empirical research results are concluded as below. (1) Manufacturers' knowledge management in global manufacturing network and knowledge management in supply chain network present remarkably positive effects on the organizational learning capability. (2) Manufacturers' knowledge management in supply chain network shows mediation effects on the relationship between knowledge management in global manufacturing network and organizational learning capability. (3) Environmental Education reveals notable moderation effects on the relationship between manufacturers' knowledge management in supply chain network and organizational learning capability.

Keywords: environmental education, knowledge management, organizational learning capability, global manufacturing network, supply chain integration

INTRODUCTION

Globalized, dynamic, and fierce market competition are the features reflecting current manufacturers' external environment (Peng & Meng, 2016). Under such environment, manufacturers have to reinforce the global competitiveness (Barrett, Balloun & Weinstein, 2009; Ferdows, 1989; Huang, Zhang, & Liu, 2013) which is realized through global marketing and global manufacturing (Rudberg & West, 2008; Ruggero, Deflorin, & Scherrer, 2016). International manufacturing initiated in 1980s and 1990s is regarded as an important composition for manufacturers acquiring competitive advantages (Ferdows, 1997). On the other hand, manufacturers have to enhance the organizational learning capability to cope with fiercely competitive and dynamic market environment (Stan & Puranam, 2017). Globalized manufacturers' organizational learning capability, under Environmental Education, is therefore concerned in the academic circle.

Meanwhile, the knowledge-based economy has knowledge become the primary source to enhance organizational learning capability. Manufacturers have to develop and cultivate the knowledge management capability and co-develop, share, and spread relevant knowledge with different bodies in the external network (Cheng, Madsen, & Liangsiri, 2010; Cheng, Chaudhuri, & Farooq, 2016; Vereecke, Dierdonck, & Meyer, 2006). Manufacturers, especially internationalized and globalized ones, have to pay attention to bodies in vertical

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Contribution of this paper to the literature

- Environmental Education does not appear moderation effect on the relationship between knowledge management in global manufacturing network and knowledge management in supply chain network.
- This study presents certain practice value on the expansion of research on international operation management and supply chain integration as well as the knowledge management practice of Organizational Learning in multinational manufacturers.

industrial chain network, i.e. suppliers and customers, and other bodies in horizontal manufacturing network in the same globalized enterprises which are getting convergent (Brennan et al., 2015; Golini, Caniato, & Kalchschmidt, 2017). The networks of such two types of manufacturers are the external networks of enterprises that, from the aspect of external network integration, manufacturers' knowledge management could be divided into knowledge management in supply chain network and knowledge management in global manufacturing network (Cheng et al., 2016). Accordingly, the relationship between manufacturers' knowledge management and organizational learning capability, under Environmental Education, is studied from the aspect of external network integration.

LITERATURE REVIEW AND HYPOTHESIS

Research on manufacturers, from the aspect of network (Barrett et al., 2009; Rudberg & West, 2008), focuses on global manufacturing network composed of multiple manufacturers evolving from single production location to various manufacturing factories (Ferdows, 1997) and supply chain network composed of manufacturers and the supply chain partners (including suppliers and customers) (Rudberg et al., 2016; Zhao et al., 2011). From the aspect of external network integration, the effects of manufacturers' global manufacturing network and supply chain network on the organizations are discussed in this study.

Under the aspect of external network integration, Chakravarty, Ferdows, and Singhal (1997) classified manufacturers' embedded network into the international comparison of manufacturers' external network, mainly focusing on the features of countries or regions, in which manufacturers' external network is, or adaptation, and the design and management of goods, people, technology, and information in the studied network. Such research was further divided into network design and optimization with physical logistics or goods flow as the representatives and network management with the creation and transfer of intangible knowledge (containing technology, decision-making, plan, and information) as the representatives (Ferdows, 1997; Vereecke et al., 2006). Knowledge management in manufacturers' external network, i.e. the creation, sharing, absorption, and transfer of intangible technology, information, and decision-making, is focused in this study.

Relationship Analysis of Manufacturers' Knowledge Management in Global Manufacturing Network and Organizational Learning Capability

This study combines the viewpoints of Rudberg et al. (2016) and regards manufacturers' global manufacturing network as the process of collaboration, information sharing, and common decision-making between manufacturers and other manufacturers of the same multinational manufacturers to fulfill the target which cannot be realized by a single factory (Ruggero et al., 2016; Shi & Gregory, 1998).

From the aspect of resource-based view, Manufacturers in multinational manufacturers could commonly create and use technology assets with other manufacturers and transfer and absorb knowledge through the manufacturing network to enhance the operation efficiency and benefit. It is the key to promote organizational learning capability (Dunning, 1993; Ruggero et al., 2016; Vereecke et al., 2006). Some research also studied organizational learning capability from different aspects (Alegre, 2008; Camps et al., 2015; Jerez-Gómez et al., 2005). For instance, Bartlett and Ghoshal (1989) considered that manufacturing network could create learning opportunities for manufacturers from the same manufacturing network to enhance the organizational learning capability. Chew, Bresnahan, and Clark (1990) indicated that innovation knowledge could be transferred from the internal manufacturer to other manufacturers in the manufacturing network to enhance the performance of the manufacturer and even the entire network. Ghoshal and Bartlett (2005) and Forsgren, Holm, and Johanson (2007) pointed out the importance of the direct exchange, especially knowledge flow, between a manufacturer and other manufacturers in the manufacturing network to the manufacturer's development potential and even learning capability. Accordingly, the following hypothesis is proposed in this study.

H1: Manufacturers' global manufacturing network knowledge management, in the same multinational manufacturers, presents significantly positive effects on organizational learning capability.

Relationship Analysis of Manufacturers' Knowledge Management in Supply Chain Network and Organizational Learning Capability

From the aspect of external network integration, a manufacturer needs to coordinate and manage the knowledge of other manufacturers of the same multinational manufacturers as well as acquire, share, and consolidate strategic knowledge and information with external partners (i.e. supply chain partners, mainly suppliers and customers) (Cheng et al., 2016; Lim, Moon, Kim, & Lee, 2017; Swink, Narasimhan, & Wang, 2007).

Knowledge coordination and management among manufacturers' external supply chains are regarded as an important integration (Golini et al. 2017; Rudberg & West, 2008). Researchers indicated that a manufacturer could more effectively plan and predict the product production and process design through the coordination and sharing of knowledge and information with key suppliers to enhance the organizational learning capability (Golini et al. 2017). Meanwhile, a manufacturer could more effectively provide market prediction and opportunity insight through tight coordination and sharing of knowledge and information with customers to better comprehend customers and establish tight links with customers to promote the operation performance and organizational learning capability (Golini et al. 2017; Swink et al., 2007; Wong, Boon-Itt, & Wong, 2011). Comprehensively, a lot of studies received the research result of positive effects of manufacturers' external knowledge management in supply chain network on organizational learning capability.

Cheng et al. (2016) also indicated that the effects of manufacturers' external supply chain integration on operation performance and organizational learning capability could be applied to deal with manufacturers in multinational manufacturers (Flynn, Huo, & Zhao, 2010; Lim et al., 2017; Wong et al., 2011). In this case, the following hypotheses are proposed in this study.

H2: Manufacturers' knowledge management in multinational manufacturers and external knowledge management in supply chain network show remarkably positive effects on organizational learning capability.

H2a: Manufacturers' knowledge management in multinational manufacturers and knowledge management in external supplier network reveal notably positive effects on organizational learning capability.

H2b: Manufacturers' knowledge management in multinational manufacturers and knowledge management in external customer network appear significantly positive effects on organizational learning capability.

Relationship Analysis of Manufacturers' Knowledge Management in Global Manufacturing Network, Knowledge Management in Supply Chain Network, and Organizational Learning Capability

A lot of researchers noticed that manufacturers in multinational manufacturers had to emphasize knowledge coordination and management in global manufacturing network as well as knowledge coordination and management of external suppliers and customers of multinational manufacturers; both global manufacturing network and supply chain network presented critical effects on the operation performance and organizational learning capability of manufacturers (Cheng et al., 2016; Golini et al. 2017; Meyer, Mudambi, & Narula, 2011; Rudberg & Olhager, 2003). Nevertheless, research on supply chain integration and manufacturing network was mainly done independently and ignored the co-influence of global manufacturing network and supply chain network (Cheng, Farooq, & Johansen, 2015; Cheng et al., 2016; Golini et al. 2017).

As a matter of fact, when taking multinational manufacturers as the research object, a single manufacturer in multinational manufacturers had to consider the effects of global manufacturing network and supply chain network, which were manufacturers' external network (Cheng et al., 2016; Golini et al. 2017; Rudberg et al., 2016). From the aspect of manufacturers' knowledge management in multinational manufacturers, some research revealed that manufacturers with high-level control and low-level knowledge coordination and management in global manufacturing network would show lower level of knowledge coordination and management in supply chain network (Birkinshaw, Hood, & Young, 2005; Gammelgaard et al., 2012). On the other hand, manufacturers with higher level of knowledge coordination and management would be more interested in higher level of knowledge coordination and management in supply chain network (Cheng et al., 2016). Meanwhile, in manufacturers' knowledge coordination and management process, the knowledge acquired from manufacturers' cooperation and technology improvement in the same global manufacturing network might be transferred to suppliers and customers to enhance the operation performance and organizational learning capability (Childerhouse & Towill, 2011; Golini et al. 2017; Miltenburg, 2009). Besides, manufacturers' requirement for knowledge coordination and management in supply chain network is based on the knowledge coordination and management in global manufacturing network and other manufacturers in (Cheng et al., 2016). Accordingly, the following hypothesis is proposed in this study.

H3: In the same multinational manufacturers, manufacturers' knowledge management in external supply chain network present remarkable mediation effects on manufacturers' knowledge management in global manufacturing network and organizational learning capability.

Relationship Analysis of Environmental Education to Manufacturers' Knowledge Management in Global Manufacturing Network, Knowledge Management in Supply Chain Network, and Organizational Learning Capability

From the effects of Environmental Education on manufacturers' knowledge management in manufacturing network and knowledge management in supply chain network, the dispersion of manufacturers in manufacturing network global would result in more difficult knowledge coordination and management among manufacturers (Rudberg & West, 2008). When Environmental Education is high, manufacturers' high-level knowledge coordination and management in global manufacturing network could enhance the organizational learning capability through knowledge management in supply chain network, and the relationship between such two external networks would be enhanced to cope with Environmental Education. On the contrary, the relationship between manufacturers' knowledge coordination and management in global manufacturing network and knowledge management in supply chain network would reduce with changing environment when Environmental Education is low (Arora, Arora, & Sivakumar, 2016; Ataseven & Nair, 2017; Kopnina & Cocis, 2017; Zhu, Krikke, & Caniels, 2017; Hosseinnezhad, 2017). In this case, Environmental Education remarkably moderates the relationship between manufacturers' knowledge management in global manufacturing network and knowledge management in supply chain network.

The following hypothesis is therefore proposed in this study.

H4: Environmental Education notably and positively moderates the relationship between manufacturers' knowledge management in global manufacturing network and knowledge management in supply chain network.

There is research on the relationship among Environmental Education, knowledge management in supply chain network, and organizational learning capability. Organizational learning capability in this study is the learning result, but not the learning process, i.e. improvement of organizational performance, which essentially discusses the effects of Environmental Education on knowledge management in supply chain network and improvement of organizational performance (Alegre, 2008; Camps et al., 2015; Jerez-Gómez et al., 2005). Koufteros, Vonderembse, and Jayaram (2005) found out significantly positive relations between market/sales plan decision-making and corporate performance under high Environmental Education and no remarkably positive relation under low Environmental Education. In this case, Environmental Education notably and positively moderates the relationship between knowledge management in supply chain network and organizational learning capability. The following hypothesis is therefore proposed in this study.

H5: Environmental Education notably and positively moderates the relationship between manufacturers' knowledge management in supply chain network and organizational learning capability.

Control Variable

In the study on the effect of organizational learning capability, other variables, e.g. organization size (Cheng et al., 2016; Swink et al., 2007), might appear influence that organization size, as the control variable, is included in the theoretical model.

RESEARCH METHODOLOGY

Theoretical Model

The research hypotheses are proposed according to the theory analysis of the relationship among Environmental Education, knowledge management in global manufacturing network, knowledge management in supply chain network, and organizational learning capability of manufacturers in multinational manufacturers to form the theoretical model for this study, **Figure 1**.

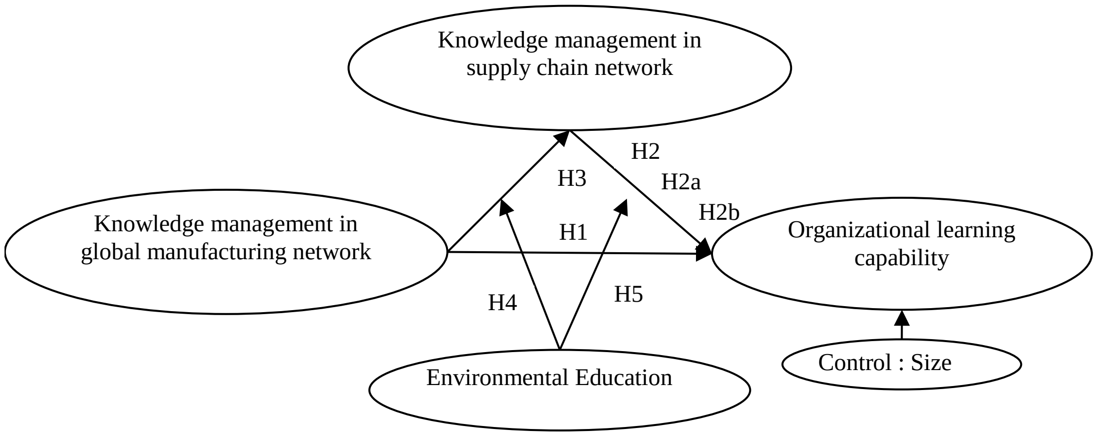

Figure 1. The relationships of the proposed hypotheses

Sample and Data Survey

The data used in this study are acquired from International Manufacturing Strategy Survey VI (the sixth version of International Manufacturing Strategy Survey, IMSS VI). The survey was done in June 2013-June 2014, about the development conditions of manufacturers three years before the end of 2012. The complete survey was announced in September, 2014. The surveyed manufacturers contained more than 50 employees and were classified in the industries in International Standard Industry Code 25-30 (ISIC 25-30).

The questionnaire is originally made in English. When it is used in other countries, researchers in the field have to translate it into the language in the country and different researchers translate it into English for the comparison. It aims to ensure the content consistency of the questionnaire in different countries.

Meanwhile, according to the research purpose, 463 manufacturers in multinational manufacturing network of 931 manufacturers from 22 countries, are selected, and the selected samples distribute in the surveyed 6 industries.

Measurement of Variable

When measuring the variables, the correspondent questions are extracted from IMSS VI. Each question is measured with Likert 5-point scale.

The measurement of the knowledge coordination and management of manufacturers in multinational manufacturers and other manufacturers is referred to the viewpoints of Colotla et al. (2003) and Cheng et al. (2015) that the knowledge coordination of information, decision-making, innovation, technology improvement, and network performance management system in past three years is measured.

The measurement of manufacturers' knowledge coordination and management in supply chain network is referred to Rudberg and West (2008) and Golini et al. (2017) that the knowledge coordination of information, decision-making, and cooperation methods of the surveyed manufacturers and the major suppliers and customers in past three years is measured.

The measurement of manufacturers' organizational learning capability in this study is the learning result, but not the learning process. Thus, they is referred to Wang and Satow (1994), Jerez-Gómez et al. (2005), and Lyu, Wu, Fu, and Xu (2016) that the simple adaptation and the organizational learning capability, i.e. manufacturers with improved operation performance (including costs, quality, delivery, innovation, service, softness, and environmental production) compared to three years ago, is used for measuring organizational organizational learning capability. Besides, organizational learning capability is divided into efficiency organizational learning capability and cost organizational learning capability because of different improvement directions of costs and efficiency.

Referring to Davis (1993) and Chen et al. (2004), the changes of market scale, customer needs, and technology faced by manufacturers are used for measuring Environmental Education.

Meanwhile, organization size, as the control variable, is included in the model to ensure the contextual validity of the result. Referring to Peng et al. (2013), the logarithm of the number of employees is used for measuring organization size.

Table 1. Regression coefficients

Independent variable	Dependent variable							
	Step1a	Step1b	Step2a	Step2b	Step3a	Step3b	Step3a	Step3b
	Suppliers' knowledge management	Customers' knowledge management	efficiency learning capability	cost learning capability	efficiency learning capability	cost learning capability	efficiency learning capability	cost learning capability
Control variable								
Logarithm of organisation size	.0.137**	0.114**	-0.020	0.015	-0.054	-0.015	-0.020	-0.014
Independent variable								
knowledge management in global manufacturing network	0.513**	0.537**	0.349**	0.206**	0.222**	0.095	0.209**	0.070
supplier knowledge management					0.248**	0.218**		
customers knowledge management							0.261**	0.254**

Note: * $p<0.05$, ** $p<0.01$

Test of Reliability and Validity

Cronbach's α is used for measuring the reliability of variables in this study. Applying SPSS19.0 to test the reliability, the results reveal the reliability of knowledge management in global manufacturing network 0.877, the reliability of supplier knowledge management in supply chain network 0.858, the reliability of customer knowledge management 0.852, the reliability of Environmental Education 0.787, and the reliability of organizational learning capability 0.906. They all confirm to the basic reliability requirement.

Exploratory Factor Analysis is used for testing the validity of data. Common factors with the accumulated variance rate not lower than 40% and the factor load larger than 0.5 are extracted, revealing the achievement of basic validity requirement. The Exploratory Factor Analysis result, with SPSS19.0, shows the validity conforming to the basic requirement.

RESULTS

Based on the theoretical model and the questionnaire survey, Regression Analysis is used for testing the hypotheses. In the process, Stepwise Regression Analysis is applied to test the relationship among knowledge management in global manufacturing network, knowledge management in supply chain network, and organizational learning capability, where the mediation effect of knowledge management in supply chain network is tested by referring to Kenny, Kashy, and Bolger (1998). The specific results are shown in **Table 1**.

Table 1 presents the regression analysis results. Manufacturers' knowledge management in global manufacturing network shows significantly positive effects on cost learning capability and efficiency learning capability in organizational learning capability that H1 is proved. Meanwhile, manufacturers' knowledge management in supply chain network reveals remarkably positive effects on cost learning capability and efficiency learning capability in organizational learning capability that H2 is proved.

To test H3, both manufacturers' knowledge management in global manufacturing network and knowledge management in supply chain network are included in the regression equation. **Table 3** lists the research results. Supplier knowledge management presents partial mediation effect on knowledge management in global manufacturing network and cost learning capability, supplier knowledge management shows full mediation effect on knowledge management in global manufacturing network and cost learning capability, customer knowledge management reveals partial mediation effect on knowledge management in global manufacturing network and cost learning capability, and customer knowledge management appears full mediation effect on knowledge management in global manufacturing network and cost learning capability. H3 is therefore proved.

Table 2. Test of moderation effect of Environmental Education on the relationship between knowledge management in global manufacturing network and knowledge management in supply chain network

Step	Variable	dependent variable: supplier knowledge management			dependent variable: customers knowledge management		
		equation 1	equation 2	equation 3	equation 1	equation 2	equation 3
1	control variable						
	organization size	0.134**	0.132**	0.132**	0.112**	0.114**	0.114**
	argument						
	knowledge management in global manufacturing network	0.520**	0.523**	0.523**	0.546**	0.543**	0.544**
2	moderator						
	Environmental Education		-0.022	-0.032		0.037	0.038
3	knowledge management in global manufacturing network*Environmental Education			-0.022			-0.034
	R^2	0.30	0.30	0. 30	0.324	0.325	0.326
	ΔR^2	0.00	0.00	0.00	0.324	0.001	0.001
	Sig. of R^2	0.000	0.411	0.580	0.000	0.343	0.383

Note: * $p<0.05$, ** $p<0.01$

Table 3. Test of moderation effect of Environmental Education on the relationship between knowledge management in supply chain network and organizational learning capability

Step	Variable	dependent variable: efficiency learning capability			dependent variable: cost learning capability		
		equation 1	equation 2	equation 3	equation 1	equation 2	equation 3
1	control variable						
	organization size	-0.058	-0.060	-0.062	-0.014	-0.012	-0.015
	argument						
	supplier knowledge management	0.195**	0.193**	0.195**	0.115*	0.118*	0.119*
	customers knowledge management	0.228**	0.232**	0.231**	0.199**	0.195**	0.193**
2	moderator						
	Environmental Education		-0.025	-0.030		0.029	0.019
3	supplier knowledge management*Environmental Education			-0.045			-0.054
	customers knowledge management*Environmental Education			0.058			0.113*
	R^2	0.148	0.149	0.050	0.078	0.077	0.085
	ΔR^2	0.148	0.001	0.002	0.078	0.001	0.007
	Sig. of R^2	0.000	0.562	0.647	0.000	0.526	0.043

Note: * $p<0.05$, ** $p<0.01$

To test H4 and H5, Environmental Education, as the moderator, is included in the regression equation to test the moderation effect. The steps are shown in **Table 2** & **3**.

Table 2 & **3** reveal no moderation effect of Environmental Education on the relationship between knowledge management in global manufacturing network and knowledge management in supply chain network that H4 is refused. Meanwhile, Environmental Education does not show moderation effect on the relationship between knowledge management in supply chain network and efficiency learning capability, but notably positive moderation effect on the relationship between knowledge management in supply chain network and cost learning capability that H5 is partially proved.

CONCLUSIONS

Under Environmental Education, the theoretical analysis and empirical research are preceded for the relationship among manufacturers' knowledge management in global manufacturing network, knowledge management in supply chain network, and organizational learning capability. The research results are concluded as followings.

(1) Manufacturers' knowledge management in global manufacturing network presents significantly positive effects on cost learning capability and efficiency learning capability in organizational learning capability. It proves H1 and is consistent with previous research on the relationship between global manufacturing

network and organizational performance (Cheng et al., 2015, 2016; Ferdows & Thurnheer, 2011; Rudberg & West, 2008). The research result explains that the knowledge coordination and management of manufacturers in multinational manufacturers and other manufacturers is getting important with the globalization development and directly determines the improvement of organizational learning capability and performance.

(2) Manufacturers' knowledge management in supply chain network reveals remarkably positive effects on cost learning capability and efficiency learning capability in organizational learning capability. It proves H2 and is consistent with the research on the relationship between supply chain integration and operation performance (Golini et al. 2017; Swink et al., 2007; Wong et al., 2011). The research result explains the important function of manufacturers' knowledge coordination and management in supply chain network to the organizational learning capability and operation performance.

(3) Manufacturers' knowledge management in supply chain network appears notable mediation effect on the relationship between knowledge management in global manufacturing network and organizational learning capability. Such a research result proves H3 and expands the research on the relationship between global manufacturing network and supply chain network recently concerned by researchers in international operation management (Cheng et al., 2015, 2016; Golini et al. 2017). Meanwhile, from the value chain theory of enterprises, manufacturers' knowledge management in global value chain is regarded as the auxiliary activity in value chain. The value realization requires the management of supply chain network, especially the management of customer network. For this reason, manufacturers have to further coordinate and manage knowledge in supply chain network, based on the knowledge coordination and management in global manufacturing network, to reinforce the organizational learning capability and promote the operation performance.

(4) Environmental Education does not appear moderation effect on the relationship between knowledge management in global manufacturing network and knowledge management in supply chain network. Since multinational manufacturers are the research objects in this study, and manufacturers in multinational manufacturers are restricted and controlled by multinational manufacturers that they are not sensitive to Environmental Education. Such an analysis is consistent with the research on the effects of autonomy of manufacturers in multinational manufacturers on the operation performance (Golini et al. 2017).

(5) Environmental Education does not reveal moderation effect on the relationship between knowledge management in supply chain network and efficiency learning capability, but shows significantly positive moderation effect on the relationship between knowledge management in supply chain network and cost learning capability. Such a research result partially proves H5 and is partially consistent with research on the moderation effect of Environmental Education on the relationship between supply chain integration and operation performance. It also explains the effects of Environmental Education on supply chain integration, which requires further study (Ataseven & Nair, 2017).

This study presents certain practice value on the expansion of research on international operation management and supply chain integration as well as the knowledge management practice of manufacturers in multinational manufacturers. Regarding the knowledge management of manufacturers in multinational manufacturers, the research results indicated that (1) manufacturers should emphasize the knowledge management in global manufacturing network and knowledge management in supply chain network, which present remarkably positive effects on organizational learning capability, (2) manufacturers in multinational manufacturers should stress on knowledge management in global manufacturing network and then emphasize knowledge management in supply chain network, rather than invest in large amount of resources at the same time, (3) manufacturers in multinational manufacturers should focus more on customer knowledge management in knowledge management in supply chain network when Environmental Education is large to enhance the organizational learning capability under high Environmental Education.

This study presents the following restrictions. (1) When stressing on the network in which a manufacturer is, the internal network is not taken into account. (2) This study merely focuses on manufacturers' organizational learning capability, but not the financial performance and strategic performance, which require further discussion in future research.

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Secondary School Mathematics Teachers' Use of Students' Learning Styles When Teaching Functions: A Case of Zimbabwean Schools

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ABSTRACT

This paper reports on a research that was done to explore how ordinary level mathematics teachers used their knowledge of their students' learning styles when teaching functions. The study was carried out at eight secondary schools in the Makoni District of Manicaland Province in Zimbabwe. The schools were selected using stratified random sampling. Twenty-five mathematics teachers at the selected schools participated in the research. Data were obtained through face to face interviews and document analysis. The findings revealed that the mathematics teachers' teaching and assessment strategies were not based on their knowledge of their students' learning styles. Information and communication technology (ICT) and audio teaching aids were not used by most of the teachers. The researchers recommended that the mathematics teachers be in-serviced on the implications of students' learning styles for mathematics teaching. The teachers also needed some in-service training on how to use different forms of ICT in mathematics teaching.

Keywords: functions, mathematics teachers, students' learning styles, teaching strategies

INTRODUCTION

In our opinion, mathematics teaching should be informed by teachers' knowledge of students' learning styles. Full knowledge of students' learning styles could help mathematics teachers in planning instruction that suits all students. A study carried out in South Africa revealed that although teachers acknowledged that learners have different learning styles, their practice did not match what they reported (Matseke, 2013). Teachers preferred teaching in ways they were taught or the way they preferred learning (Patel & Singh, 2014). Haas (2003) reported that mathematics classrooms were largely verbal environments in which instructions were given verbally with follow ups done on the chalkboard. The environment forced students to memorise formulae, algorithms and theorems. Such an environment is suitable only for students with strong processing skills.

The purpose of the current research study was to explore how mathematics teachers in Zimbabwe used their knowledge of their students' learning styles when teaching functions to ordinary level mathematics students. The researchers chose to carry out the study on the teaching of functions because they considered functions as the backbone of advanced level mathematics. Haas (2003) supported this by reiterating that the understanding of the theories of functions is vital in enabling students to understand advanced mathematics.

Haas (2003) defined a function as a mapping or an operator relating an input set of numbers to an output set of numbers so that each element of the input set is related to only one element of the output set. The input set is called the domain set and the output set is referred to as the codomain set. Denbel (2015) asserted that functions can be in different representations. The representations include graphs, mapping diagrams, verbal statements, tables and notations like $f: x \to y$ or $f(x) = y$.

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Contribution of this paper to the literature

- To present to the world how the mathematics teachers use their knowledge of their students' learning styles in teaching functions.
- The results revealed that the mathematics teachers rarely use ICT in mathematics teaching.
- Some mismatch existed between the teacher's teaching strategies and the students' learning styles.

When teaching functions, the Ministry of Primary and Secondary Education (MOPSE) Mathematics Syllabus in Zimbabwe for Forms 1-4 (2015) stated that teachers should assess the students' abilities to do the following;

1. Apply mathematical symbols, terms and definitions.
2. Draw and interpret tables, graphs, charts and diagrams accurately.
3. Make effective use of a variety of information and communication technology system tools in solving problems.
4. Solve routine and non-routine problems using appropriate formulae, algorithms and procedures.

Research Question

The current research was guided by the following research question: How do secondary school mathematics teachers use their knowledge of students' learning styles in teaching functions in mathematics? To help answer this research question, the following sub-questions were formulated:

1. What are the teaching strategies used by mathematics teachers when teaching functions?
2. What are the teaching aids used by the teachers when teaching functions?
3. How do the teachers assess their students' progress in learning functions?

LITERATURE REVIEW

Al-balhan (2007) defined learning style as the most comfortable way a learner can learn. It is the learner's preferred way of learning. Barke (2009) argued that learning styles are an integration of cognitive processes and learner behaviour. Learners have different learning styles. Differences exist in the way information is perceived, processed and communicated by learners (Barke, 2009; Felder, 2010; Patel & Singh, 2014; Powell & Powell, 2016).

Research on learning styles led to learners being categorised in many ways (Abuzaid, Nadarajan, & Naimie, 2016; Honey & Mumford, 1986; Kolb & Kolb, 2005).One of the ways of classifying learners based on their learning styles was given by Perini, Silver and Strong (2000). Perini, Silver, and Strong classified mathematics learners as shown in **Table 1**.

Table 1. Classification of mathematics learners (Perini, Silver & Strong, 2000)

Class of learners	Description	Preferred learning activities
Mastery maths learners	• Learn in a step by step manner • Enjoy solving problems by following algorithms, theorems and formulae • Have difficulties in solving non-routine problems • Prefer teachers who coach them • Judge learning by clarity and practicality of the concepts learnt	Application of algorithms, formulae and theorems
Interpersonal maths learners	• Learn through dialogue and collaboration • Are interested in how mathematics concepts help in real life • Have difficulties in solving problems as individuals • Do not like solving problems that do not have real life application • Want teachers who appreciate their successes and struggles • Judge mathematics learning by its potential to help people	Group discussions
Understanding maths learners	• Seek to understand why mathematics concepts learnt work • Like problems that allow them to prove and explain reasons for taking certain decisions • Seek patterns in mathematics concepts • Have difficulties in working with others in solving problems • Judge learning by use of evidence and logic	Proving why concepts work in real life working as individuals in solving problems
Self-expressive maths learners	• Use imaginations to solve mathematics tasks • Enjoy solving non-routine problems • Generate possible solutions by exploring alternatives • Judge learning by originality of the concepts learnt	Solving non-routine and project-like mathematics problems

Due to the diverse nature of students' learning, Perini, Silver, and Strong (2000) advised mathematics teachers to use a variety of teaching strategies. According to Perini et al., students should be assisted in recognising their learning styles through the use of four dimensions of mathematics learning. The four dimensions are computation, explanation, application and problem solving. It is important for mathematics teachers to align teaching and assessment strategies with students' learning styles as they go through the four dimensions of mathematics learning. Dasari (2006) reinforced the need to align teaching strategies and students' learning styles by saying that students retain information longer if they are taught in their preferred learning style.

Bender and Waller (2011) advocated differentiated teaching to ensure that all learners benefit from the learning process. Differentiated teaching as defined by Tomlinson (2001) entails tailoring instruction so as to meet individual needs of the learners. Laura (2017) added by saying differentiated teaching means the teacher observes and understands differences and similarities among students and uses the information to plan instruction. Weselby (2017) summarised differentiated teaching as designing a lesson based on students' learning styles. According to Weselby, differentiated teaching involves continuous formative assessment and adjustment of lesson content until it meets students' needs. Tomlinson (2001) suggested that differentiated teaching can be done in three areas of teaching which are content (what the learner learns), process (how the content is mastered by the learner) and product (how the learning process is assessed and evaluated).

Umugiraneza and Bansilal (2017) purported that the most common strategies used in mathematics learning are direct instruction, cooperative learning and problem based instruction. Moore (2012) proposed alternative mathematics learning strategies which included manipulation of objects, real life application of mathematics concepts, integration of information and communication technology devices and use of games. Moore emphasised on the use of games in mathematics learning by saying games help in developing mathematical thinking. On the other hand, White (2012) noted that the use of manipulatives like drawing instruments and computers create more concrete representations of mathematical concepts in learners than any other method. The Ministry of Primary and Secondary Education (MOPSE) Mathematics Syllabus in Zimbabwe for Forms 1-4 (2015) suggested the following teaching strategies to be used in teaching mathematics concepts: discussions, expositions, demonstrations, simulations, educational tours and presentations by experts. The MOPSE syllabus suggested that mathematics teachers use relevant texts, information and communication technology tools, the environment, braille materials, talking tools and software when teaching mathematics.

Yousuf and Behlol (2015) supported the use of information and communication technology (ICT) systems when teaching mathematics by reporting that the application of ICT as a teaching strategy was found to be effective as compared to traditional strategies. ICT as defined by Mohanty (2011), refers to all technological tools and resources used to communicate, create, disseminate, store and manage information. It includes computers, the internet, broadcasting technologies (radio and television), cell phones and calculators. Mohanty proclaimed that ICT has many benefits to students. One of the benefits is that it gives students an opportunity to collaborate on assignments

Table 2. Demographic information of the mathematics teachers (n=25)

	Teaching experience in years			Highest professional qualifications			
	Less than 5	**Between 5 and 10**	**More than 10**	**None**	**Diploma**	**Bachelor's degree**	**Master's degree**
Females	2	2	4	1	4	3	0
Males	3	6	8	3	10	2	2
Total	5	8	12	4	14	5	2

with people inside and outside school through flexibility of anywhere, anytime access. Tinker (2017) reported that computer software packages were used in schools in Mathematics teaching. Tinker noted that the widely used packages in teaching functions were ClarisWorks, Microsoft works, Alice and Stella. However, a study carried out in Ghana revealed that mathematics teachers did not integrate ICT in their mathematics instruction (Agyei & Voogt, 2010). According to Agyei and Voogt, the mathematics teachers in Ghana lacked knowledge about how ICT can be integrated in mathematics teaching.

Apart from teaching methods that are student centred and sensitive to students' learning styles, assessment of the learning process is also a very important aspect in learning mathematics concepts like functions. Boaler (2016) proposed assessment that focuses on improving understanding of mathematics concepts. Boaler reiterated that mistakes made by students should present a powerful learning opportunity which teachers should take advantage of by providing immediate feedback on students' actions and how the actions can be improved.

The analysis of the literature on mathematics teaching indicated that the teaching of functions at ordinary level calls for teaching and assessment strategies that take into consideration the differences in students' learning styles.

MATERIALS AND METHODS

Data used in this research were obtained from twenty five mathematics teachers at eight secondary schools in the Makoni District of Manicaland Province in Zimbabwe. The schools were selected using stratified random sampling method. This was done to ensure that the sample included schools under different responsible authorities. Black (1999) supported the use of stratified random sampling by saying that stratified random sampling ensures that groups are proportionally represented in the sample. All mathematics teachers at the selected schools participated in the research.

The demographic information of the mathematics teachers who participated in the research is shown in **Table 2**.

Permission to carry out the research was sought from the Zimbabwean office of the Permanent Secretary in The Ministry of Primary and Secondary Education as well as from Manicaland Provincial Education Director. At school level, the researcher got permission from school heads before meeting the mathematics teachers. The mathematics teachers were given a participant information sheet which explained the purpose of the research and the rights of the participants. The teachers were asked to fill in a consent form before participating in the research. The researchers clearly explained to the mathematics teachers that their participation in the research was voluntary.

Data were collected through face to face interviews. Document analysis was then done to triangulate the data obtained through the face to face interviews. The documents analysed were the mathematics teachers' schemes of work and lesson plans. An interview guide and a document analysis checklist were prepared in advance. An interview session took not more than thirty minutes. Audio recorders were used to help in capturing data during the face to face interviews. Statements given by the teachers during the interviews were transcribed verbatim.

The data collected were analysed qualitatively. During data cleaning, similar statements from the teachers were used to develop themes. The themes were then used in data analysis. Verbatim statements made by the teachers were used to support and illustrate the research findings.

FINDINGS

Teaching Strategies used by the Mathematics Teachers when Teaching Functions

The data obtained from the mathematics teachers revealed that all the participants used both individual and group activities when teaching functions. Further information obtained from the teachers' schemes of work indicated that the teachers used groups of not more than three students during group work sessions. However, group work was used on rare cases as shown by the teachers' lesson plans. When asked to comment on the effectiveness of group work in teaching functions, one of the teachers said:

> *"Students get an opportunity to suggest what they consider solutions to given problems unlike in situations where they learn as individuals or as the whole class. I normally do not use group work due*

Table 3. Activities done by students during lessons on functions (n=126 lessons)

Activities	Frequencies	Percentages
Identifying patterns	5	3.97%
Applying learnt concepts in solving everyday life problems	52	41.27%
Using imaginations in solving real life problems involving functions	6	4.76%
Drawing, sketching and plotting graphs of functions	107	84.92%
Solving non-routine problems involving functions	7	5.56%
Solving project-like questions involving functions	27	21.43%
Locating points on Cartesian planes	13	10.32%
Using graphs of functions to estimate values	7	5.56%

Table 4. Reasons given by the teachers for not using ICT in teaching functions (n=25 teachers)

Reasons	Frequencies	Percentages
Lack of time	5	20%
Teacher not computer literate	17	68%
Lack of availability of the needed equipment	19	76%
Lack of training on using ICT in mathematics teaching	13	52%
No constant supply of electricity	5	20%
School authority not supportive	2	8%
Negative attitude on the part of the teacher	2	8%

> *to shortage of time. Thirty five minutes allocated to a mathematics lesson is not enough for me to use group work effectively. It is difficult to get feedback from the students. I propose that the lessons be allocated up to an hour. Imagine students want to make a table of values for the function f(x) = x3 +5, draw the graph to a given scale and then give feedback to the class. It cannot be done in thirty five minutes."(Ms A, pers.com).*

Data obtained from one hundred and twenty-six lessons that were analysed revealed that the mathematics teachers used the activities shown in **Table 3** when teaching functions at ordinary level.

Twenty one teachers (84%) indicated that they rarely gave non-routine and project-like questions to their students. One of the teachers said:

> *"Non-routine and project-like questions are time consuming and challenging. I do not think my students are able to solve these questions. I do not give these problems to my students. However, with the newly introduced curriculum, there is no way out. I have to find time for the questions."(Mr B, pers.com).*

Teaching Aids used by the Mathematics Teachers in Teaching Functions

The use of ICT in teaching functions was not common in all the schools that were sampled. Calculators were the only electronic device used in all the schools. Only one teacher indicated that he sometimes used computers in teaching functions. The teacher said:

> *"My students enjoy learning through the use of computer systems. I sometimes ask them to use excel in drawing graphs. For instance, if you check on the exercise that I gave on Monday. I asked the students to draw bar graphs showing marks they obtained in this month's tests. Each student had to show his or her marks on a bar graph."(Mr C, pers.com).*

The reasons given by the teachers for not using ICT in their lessons on functions were as indicated in **Table 4**.

Commenting on the use of ICT in mathematics teaching, one of the teachers had the following to say:

> *"I need to learn to use the computer. The students are far ahead of us in terms of technology. How can I try to use ICT in my lessons when the students know better than me? I will end up embarrassing myself."(Mr D, pers. com).*

The data obtained from the teachers revealed that all the mathematics teachers who participated in this research did not use audio teaching aids. In one hundred and seven (84.92%) lessons planned, the teachers wanted their students to draw graphs and diagrams from given functions. The students used rulers, protractors and compasses. Visual aids were a common feature in ninety-one lessons (72.22%) planned by the teachers. The visual aids included charts with graphs, question strips and chalkboard with exercises or diagrams. Sixteen teachers (64%) had the view

Table 5. Skills assessed by the mathematics teachers and how the skills were assessed

MOPSE skill	Examples of tasks done by students (taken from the teachers' lesson plans)	Group work or individual work	Class of learners catered for	Estimated time given
Applying mathematical symbols, terms and definitions Drawing tables and graphs accurately Interpreting graphs	Given $f(x) = x^2 + 2\ for$ $x \in \mathbb{Z}$ (i) construct a table of values for -2≤x≤8 (ii)draw the graph of the function for the given domain using a scale of 2cm representing 1 unit on both axes (ii) using the graph, find the minimum value of f(x)	Individual work	Understanding maths learners and mastery maths learners	25 minutes
Making effective use of information and communication technology system tools in solving problems	Using excel, draw a bar graph of the marks that you obtained in your monthly mathematics tests in 2017	Individual work	Self-expressive maths learners and understanding maths learners	20 minutes
Solving routine and non-routine problems using appropriate formulae, algorithms and procedures	1. In pairs, perform the following tasks. (i) Draw circles with the following radii: 7cm,14cm and 28cm (ii)Using the piece of wire provided, measure and record the circumferences of the circles (iii) Divide the circumferences by their respective radii (iv) Hence, express the circumference of a circle as a function of the radius of the circle (iv)Use the function to calculate the circumference of a circle with radius 21m long	Group work	Interpersonal maths learners, self-expressive maths learners and Mastery maths learners	45 minutes
	2. The number of goats at a farm is five less than twice the number of sheep at the farm. Express the number of goats in terms of the number of sheep. If there are ten sheep at the farm, how many goats are at the farm?	Individual work	Understanding maths learners and mastery maths learners	10 minutes
Interpreting graphs (identifying patterns)	3. Draw the graphs of the function $f(x) = ax^2$ for $a = 2, a = -2,$ $a = 1\ and\ a = -1$ $for - 3 < x < 3$. Comment on the nature of the graphs for $a < 0$ and $a > 0$	Individual work	Understanding maths students	30 minutes

that using visual teaching aids was the most effective way of teaching functions. Five teachers (20%) indicated that they used visual aids simply because they were readily available in their area as compared to other teaching aids.

How the Mathematics Teachers Assessed their Students' Progress during Lessons on Functions

Table 5 summaries how the mathematics teachers assessed their students' work on functions.

It was noted that all the teachers used presentations as a way of assessing their students' ability to communicate ideas. The teachers said they gave their students opportunities to present their work to their peers after group discussions. It was however reiterated that not all the students got the opportunity to present due to lack of time. One of the teachers said:

> *"I allow students to work in groups. This enables them to learn to communicate ideas to peers. Due to shortage of time, not all of them get the opportunity to express themselves to their peers. At times we reduce the number of students in a group so that we increase the chances for every student to at least say something."(Mr L.pers.com).*
>
> *Apart from the skills given in **Table 5**, the teachers pointed out that they also assessed their students' neatness, accuracy in making calculations, ability to identify mathematical patterns and ability to perform given tasks within given timeframes. Neatness was assessed in the context of graphs and diagrams drawn. The following were statements from some of the teachers:*

"I also assess the neatness of the graphs and sketch diagrams drawn by the students. Diagrams should be clear and presentable."(Mr M. pers.com).

"I am very particular about the time my students take in performing given tasks. Time management is very important for my students to pass exams. However it is a case of being fast and accurate. Calculations must be done accurately especially when constructing tables of values." (Ms N.pers.com).

DISCUSSION

This study revealed that the mathematics teachers used both individual and group work when teaching functions. According to the teachers, group work was rarely used. Perini et al. (2000), affirmed that 'understanding maths learners' learn better if they learn as individuals than in groups while 'interpersonal maths learners' learn better in groups than as individuals. The data obtained from the mathematics teachers exposed that 'interpersonal maths learners' were not fully catered for during lessons on functions. They were denied an opportunity to collaborate in groups. However, since it is not possible to use group work all the time, it is important to get learners to take note that at times they need to also learn in individual settings by reflecting and interacting with the material to be learnt.

The data obtained from the teachers indicated that in most of the lessons on functions, students were instructed to draw, sketch or plot graphs. These activities were in line with the requirements of the Ministry of Primary and Secondary Education Syllabus in Zimbabwe for Forms 1-4 (2015) which stipulated that by the end of the learning period, students should be able to draw and interpret tables, graphs, charts and diagrams accurately. The same syllabus required students to solve non-routine problems on functions. However, twenty–one of the mathematics teachers indicated that they rarely gave non-routine problems to their students. This was a disservice to 'self-expressive maths students' since they enjoy solving non-routine problems (Perini et al., 2000).

According to Perini et al. (2000), 'understanding maths students' learn by identifying patterns in mathematical concepts. However, only 3.97% of the lessons planned by the mathematics teachers gave the students an opportunity to identify patterns. The findings of this research also revealed that the mathematics teachers did not use games when teaching functions. Games are regarded as necessary for the students as they develop mathematical thinking in the students (Moore, 2012).

Tinker (2017) indicated that computer software packages like Stella were used in schools in United States of America in mathematics teaching. However, the current research revealed that only one of the mathematics teachers reported using computers when teaching functions. The only electronic gadget used by the teachers in their lessons was an electronic calculator. The results of the current research were similar to those obtained by Agyei and Voogt (2010) in Ghana. Agyei and Voogt observed that mathematics teachers in Ghana did not use computers in mathematics teaching.

According to the mathematics teachers, the students' ability to apply learnt concepts and the ability to communicate ideas were assessed during lessons on functions. It was also noted that students were involved in hands-on activities during the lessons. Students were given an opportunity to draw, plot and sketch graphs of functions. According to Perini, Silver and Strong (2000), these tasks are important for 'mastery maths learners'. The findings exposed that 'self-expressive maths learners' were not fully catered for by the teachers since the teachers rarely gave non-routine exercises to their students.

RECOMMENDATIONS

Based on the results obtained from the research, the researchers recommend that it is important for mathematics teachers to attend in-service workshops on the implications of students' learning styles on mathematics teaching. It is important for teachers to know the differences in their students' learning styles before planning instructions. This knowledge could help teachers during their lesson preparation to ensure that all students benefit from the planned instruction. Application of differentiated teaching strategies require full knowledge of students' learning styles.

The use of ICT in mathematics teaching cannot be ignored. It was discovered in the research that the teachers did not use ICT mainly because of computer illiteracy and lack of computer resources in schools. It is therefore important for school administrators to acquire ICT devices for use in mathematics lessons. The teachers need training on how to integrate ICT in mathematics teaching.

Mathematics teaching requires the use of a variety of teaching aids so that students of different learning styles benefit. Teachers should vary teaching aids. The researchers recommend that school authorities assist mathematics teachers in acquiring teaching aids for use in mathematics lessons.

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Job Stress, Burnout and the Relationship among the Science and Mathematics Teachers in Basic Education Schools

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ABSTRACT

A questionnaire about job stress and burnout among the Science and Mathematics Teachers in basic education schools was conducted among the Science and Mathematics Teachers in Xi'an city, Xianyang city and Zhanjiang city. The result is stated as follows: 1) The modern society puts great stress on the Science and Mathematics Teachers in basic education schools. 2) Stress of interpersonal relationship positively predicts one's decreased sense of achievement, emotional exhaustion and depersonalization while employment stress also positively predicts on emotional exhaustion. However, by contrast, stress of job reputation has a backward prediction on depersonalization. 3)the Science and Mathematics Teachers in basic education schools are under stress of career development, workload, examinations, interpersonal relationship, roles, responsibility and unemployment. These stresses have positive correlation with emotional exhaustion obviously. It comes to the conclusion that job stress in different surroundings leads to the 3 reasons for the Science and Mathematics Teachers' job burnout, which shows a remarkable correlation between job stress and job burnout. Some advice should be implemented, which is for Chinese government, education administration, the society, professional association, school peers, the individual.

Keywords: basic education schools, job stress, job burnout, science and mathematics teachers

INTRODUCTION

The reform of the new curriculum of education has entered a critical period and the social sectors are of great concern, and the performance wage reform of the Science and Mathematics Teachers in the last two years has been controversial at the grassroots level. These concerns and controversies have led to the development of the Science and Mathematics Teachers' living conditions, including the stress of the Science and Mathematics Teachers, social support, coping styles and job burnout. To improve the Science and Mathematics Teachers' happiness, first of all, we should fully understand the Science and Mathematics Teachers' job stress and job burnout. Being a teacher seems to be easy. However, they suffer from a lot of strong stress and no less than other professions. In the early time, some scholars defined the job stress of the Science and Mathematics Teachers as negative and unhappy feelings or emotions like anxiety, depression, anger or rage, which all came from the job. This definition stressed that the Science and Mathematics Teachers thought their work environment threatened their health and even their dignity. The word "stress" is developed as job stress of the Science and Mathematics Teachers in the educational field. The job stress of the Science and Mathematics Teachers in basic education schools is related to physical and mental health of the Science and Mathematics Teachers as well as whether students can complete their missions or not. That is to say, it has much to do with the development of the whole elementary education. This survey in the

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Contribution of this paper to the literature

- The Science and Mathematics Teachers should constantly improve their personal cultivation, honing their will quality and enhancing their ability to resist the stress of work.
- The self-efficacy represents the faith of the Science and Mathematics Teachers toward their teaching ability. This factor directly affects how the Science and Mathematics Teachers choose their teaching activities, how they attribute their success or failure to teach, and how they regulate their moods.
- It is necessary to set up a social support system aimed at the Science and Mathematics Teachers in the next curriculum reform to raise the Science and Mathematics Teachers' awareness of subjective social support and encourage them to use social support positively.

form of questionnaires, which focuses on the Science and Mathematics Teachers in middle schools, properly handled the collected data, compared the difference of denotable variables in job stress and looked into the correlation between job stress and work environment. It aims to find a workable solution to the job stress of the Science and Mathematics Teachers and provide a more effective educational administration policy to better teacher' s psychological quality (Cho & Tee, 2018).

Burnout is a term used to describe a state of physical, emotional, and mental exhaustion, which occurs after long-term exposure to situations that are emotionally demanding (Montgomery, Panagopolous, & Benos, 2006; Furner, 2017). Job burnout refers to physical and mental exhaustion caused by job stress (Dorman, 2003). The Science and Mathematics Teachers, especially those who work in schools with a lack of resources, are faced with great stress, which even have an impact on their body and mental health (Ben-Zur, 2002). As a result, it never ends that the Science and Mathematics Teachers punish students physically or even commit suicide. Job stress has been found to be strongly associated with burnout in previous research studies (Wu et al. 2007). The Science and Mathematics Teachers in basic education schools, like other practitioners, are under stress, such as stress from workload and their job reputation along with stress from teaching and students and parents which doesn't exist in other occupations (Mark et al., 2006). So far, China has carried out some reforms in schools' personnel system (Borg et al., 1989), which not only changes the situation that employment of all staff members by contract in primary and middle schools leads to the Science and Mathematics Teachers' austere and stable life but also add more stress on the Science and Mathematics Teachers. Later, one-child policy was carried out to limit the population, which will end up with a decreasing number of students registered and force schools to cut the number of the Science and Mathematics Teachers accordingly (Betoret, 2006). All the stress mentioned above will confront the Science and Mathematics Teachers in primary and middle schools with some problems (Borg et al., 1991), such as unprecedented social crisis and challenges for their career life. However, great job stress also plays a part in the job burnout of the Science and Mathematics Teachers in primary and middle schools, which may end in something bad. From the current situation, researches on the Science and Mathematics Teachers' job stress are far from enough; especially some concepts like job burnout haven't been empirically studied in China.

The paper mainly probes into the relationship between job stress and burnout among the Science and Mathematics Teachers in basic education schools. The problem whether the current job stress directly leads to job burnout is also covered in the paper. A lot of research has confirmed that the coping styles and social support are important and direct factors in stress function system, which helps develop a more appropriate and effective social support system to advance the curriculum reform, guarantee physical and mental health of the Science and Mathematics Teachers as well as promote the Science and Mathematics Teachers' career growth and further sustainable development in education (Guglielmi et al., 1998).

METHODOLOGY

Research Objects

This small-scale study investigates the Science and Mathematics Teachers in basic education. 1400 questionnaires were randomly given out to the Science and Mathematics Teachers in basic education schools in Xi'an city, Xian yang city and Zhanjiang city, whose valid return rate was 69.7%. That is, there were 977 valid questionnaires, of which 201 were from high schools, 312 from middle schools, 278 from primary schools and 186 from nursery schools. They were made up of 396 male of the Science and Mathematics Teachers and 581 female of the Science and Mathematics Teachers.

Research Methods

Job stress questionnaire among the Science and Mathematics Teachers in basic education schools

Two standardized questionnaires, Karasek's job content questionnaire (JCQ) and Siegrist's ERI questionnaire, were used to obtain information on job stress. Chinese versions of these two questionnaires have both demonstrated good reliability and validity (Li et al. 2004). This questionnaire focuses on 5 aspects, such as the Job condition, Teaching and learning conditions, workload, relationships, and fun. Based on Likert Scale, it consists of 24 questions with 4-level scoring.

Job burnout questionnaire among the Science and Mathematics Teachers in basic education schools

Maslach Burnout Inventory–General Survey (MBI-GS) was used to measure burnout (Maslach & Jackson, 1981). The Chinese version of the MBI-GS was revised and validated by Li and Shi in 2003 and has been demonstrated good reliability and validity in the Chinese population (Wu et al. 2007). In this study the questionnaire, using Likert Scale, consists of 22 items with a 7-level scoring, from "6-appearance each day" to "0-never appearance". The 3 dimensions are decreased sense of achievement, depersonalization and emotional exhaustion.

Social support rating scale (SSRS)

Social support rating scale (SSRS) was designed by Xiao Shuiyuan in 1986 (Xiao, 1986), to evaluation subjects, objective support, subjective support and utilization of support. SSRS are widely used in China, is generally believed that the scale design is basically reasonable, and the entry is easy to understand without ambiguity. Also it has good reliability and validity. The coefficient of homogeneity of the scale in this study was 0.75.

Simplified Coping Style Questionnaire (SCSQ)

Simplified Coping Style Questionnaire (SCSQ) was designed by Xie Yaning to assess coping style (Xie, n.d.). The questionnaire, a total of 20 items, lists attitudes and practices that people may adopt as facing with setbacks or some difficulties in life. Never: 0, occasionally: 1, sometimes: 2, often: 3. It includes two dimensions: positive coping and negative coping strategies, respectively, to assess the relative stability of individuals in life. Coping style total scores = positive coping scores - negative coping scores. The higher the score is, the more positive the coping style.

Statistical Analysis

Single factor correlation analysis (Pearson correlation coefficient) and one-way analysis of variance (One Way ANOV) are performed by a software SPSS15.0.

RESULTS AND ANALYSIS

The Source of job stress among the Science and Mathematics Teachers in basic education schools

The Science and Mathematics Teachers shared their answers to the open-ended question what is the most stressful thing the Science and Mathematics Teachers have come across in their work lately. The result (**Table 1**) shows that examination puts the most stress on the Science and Mathematics Teachers, while stress from parents of students lists the first in western countries.

Table 1. The Source of job stress among the Science and Mathematics Teachers in basic education schools

	Select Number Frequency	Selection Percentage (%)
Examination	102	31.2
Workload	58	17.7
Job Reputation	48	14.7
Unemployment	41	12.5
Parents Of Students	33	10.1
Role And Responsibility	21	6.4
Interpersonal Relationship	15	1.6
Career Growth	6	1.8
Others	3	0.9

Table 2. The correlation between job stress and job burnout among the Science and Mathematics Teachers in basic education schools

	Emotional Exhaustion	Decreased Sense of Achievement	Depersonalization
Examination Stress	0.126*	0.031	-0.036
Workload Stress	0.172***	0.077	0.027
Role Duty Stress	0.147**	-0.017	0.035
Employment Stress	0.199***	0.039	0.030
Career Development Stress	0.154**	0.055	0.056
Job Prestige Stress	0.051	0.035	-0.076
Parents and Students Stress	0.050	-0.041	-0.001
Interpersonal Stress	0.299***	0.144**	0.168**

Note:*P<0.05, **P<0.01, ***P<0.001

The Seriousness of Job Stress among the Science and Mathematics Teachers in Basic Education Schools

In this group, the total seriousness of job stress stands at 3.81±0.91, stress from examination 3.94±0.98,stress from job reputation 3.81±1.24, stress from workload 3.5±1.04, stress from unemployment 3.47±1.20, stress from career growth 3.24±1.16, stress from parents of students 3.10±1.05, stress from responsibility 3.03±1.04, and stress from interpersonal relationship 2.4±1.11. In the 8 aspects, only the stress from interpersonal relationship averages is less than 3, and the rest is all over 3.

The Correlation between Job Stress and Job Burnout

From Table 2, we know that the stress from interpersonal relationship is in direct ratio with the 3 reasons for job burnout. 6 out of the 8 aspects show a direct ratio with emotional exhaustion.

Through further attribution analysis, we find: 1) The job stress of primary and secondary school of the Science and Mathematics Teachers in China mainly affects the emotional exhaustion and depersonalization in their job exhaustion, and the personal achievements of the Science and Mathematics Teachers are mainly affected by the stress of teaching security. 2) The stress source with obvious predictive effect on emotional failure is job security and teaching guarantee; 3) the stressors that have a significant predictive effect on personality disintegration are interpersonal factors; 4) the teaching guarantee factor in job stress has a certain predictive effect on personal achievement (Shang et al., 2013). It can be seen from the survey results that the Science and Mathematics Teachers in primary and secondary schools are faced with job stress and job exhaustion, but specific to different schools, disciplines and individual, the Science and Mathematics Teachers' job exhaustion is quite different. Job and teaching security, though much better than in the past, remains the primary source of job stress for the Science and Mathematics Teachers. The reason is that the new curriculum reform put forward new requirements, so there is such a causal relationship: the new curriculum is transformed into the Science and Mathematics Teachers more professional stress!

Multiple Regression Analysis of the Science and Mathematics Teachers' Job Burnout and Its 3 Factors

Based on the existing research results at home and abroad and the above relations, the job stress, social support (including subjective support, objective support and utilization of support), and demographic variables as

Table 3. Parameter values of multiple regression analysis ofthe Science and Mathematics Teachers' job burnout

	Predictive Variable	R^2	*F*	*Beta*	*T*
JB	Job Stress	0.203	249.486***	0.427	15.611***
	Social Support	0.285	190.467***	-0.280	-10.232***
EE	School Level	0.193	233.095***	-0.447	-15.298***
	Exploitation	0.216	134.841***	-0.139	-4.534 ***
	Job Stress	0.236	101.003***	0.142	5.004***
	Negative Coping	0.238	77.090***	0.063	2.077***
D	Job Stress	0. 177	209.554***	0.369	13.371***
	Utilization	0. 244	157.799***	-0.232	-7.647***
	School Level	0. 308	145.541***	0.282	10.338***
	Subjective Support	0. 324	117.444***	-0.150	-4.813***
DS	Job Stress	0.182	217.517***	-0.356	-12.561***
	School Level	0.243	157.413***	-0.289	-10.188***
	Subjective Support	0.270	121.136***	0.173	6.076***

Remark: *$p<0.05$, **$p<0.01$, ***$p<0.001$. JB= job burnout, EE= emotional exhaustion, D= depersonalization, DS=decreased sense

independent variables, job burnout and its 3 dimensions for the dependent variable stepwise regression analysis, the results such as **Table 3**.

Variables including social support, negative coping, job stress, and school level respectively have significant predictive effect on job burnout and its 3 factors (decreased sense of achievement, depersonalization and emotional exhaustion) among the Science and Mathematics Teachers in basic education schools (Shang et al., 2016). Based on job burnout as the dependent variable, we investigate the job stress's predictive effect on social support, and it was found that job stress and social support had a predictive effect on it. In order to further explore the adjustment function of social support, regardless of the level of job stress, the level of job exhaustion is always low. After further study, we found out job stress could be basically thought of no interaction on what social support influences on job burnout.

DISCUSSION

Stress Source and Job Stress

According to the research, today the Science and Mathematics Teachers in China have to deal with the stress from parents of students, which illustrate the specialty of teaching. They also have to deal with the stress from job reputation, salary, especially the most stressful examination that is seldom reported in foreign countries, which shows its variety. The stress from examinations performs their unique effect in China and has a great impact on the body and mental development of the Science and Mathematics Teachers, parents and students. In China, the Science and Mathematics Teachers in primary and middle schools have to face the suppression of social system, the expectation of schools and parents together with the development of students. With the increasing stress, the Science and Mathematics Teachers are easy to fall into anxiety, which will in return influence their physical and mental health and work efficiency. And this is a never-ending cycle.

This study examined the intensity of job stress perceived by primary and secondary school of the Science and Mathematics Teachers. It found that nearly 81%the Science and Mathematics Teachers of primary and secondary school thought they were facing greater job stress. According to the stress source, the top 10 items were: (1) High job requirement. (2) Sense of knowledge crisis; (3) having to do present school work that is disliked; (4) Few opportunities for improving and learning; (5) Higher and higher certificate in education; (6) Less fun; (7) Not being recognized of work; (8) Too many boring things to do every day; (10) Superior mistrust.

The curriculum reform has been designed and implemented by education experts for many years. Although the blueprint is very beautiful and urgent, it has not fully aroused the enthusiasm of the first-line the Science and Mathematics Teachers and greatly reduced the effectiveness. At present, there is still a large gap between the Science and Mathematics Teachers' ability to handle new curriculum reform and the high requirement of new curriculum reform, so forced implementation can only invite complaints. They generally reflect that the requirements are too high to achieve! On the other hand, they also promote the continuous development of the Science and Mathematics Teachers. They are very eager to meet the requirements of the new curriculum, so the biggest stress impact event is the sense of knowledge crisis. Fewer opportunities for charging and learning; Schools are becoming more demanding. With the increasing speed of knowledge update, primary and secondary schools are demanding higher education requirements, and the Science and Mathematics Teachers are struggling to cope with the assessment and workload, so the stress is obvious. Of course, the teacher feel have no time to study, work long hours and work requirement is high, the reason is that the implementation of the new curriculum reform for large area, the quantity and quality of teacher is difficult to follow up, assess tougher task is aggravating. In the above 10 events, “Not being recognized of work” and “Superior mistrust” also reflects the strong value conflict between the current education utility and the concept of new curriculum. The school’s leadership still evaluates the Science and Mathematics Teachers with years of grades and graduation rates, and the Science and Mathematics Teachers may not be appreciated if they have new teaching practices. Many school leaders have become double-faced people, and on the one hand, they have promoted the new curriculum reform to meet the superior’s examination (Mark et al., 2006). On the other hand, they try their best to do exam-oriented education to increase the rate of graduation. So the survey found that many schools actually have two sets of curricula, so that they can cope with the new curriculum.

At present, a huge contradict exists ahead of schools and the Science and Mathematics Teachers that schools have abundant the Science and Mathematics Teachers while their teaching quality isn’t improved accordingly (Friedman, 1991). Schools are carrying out personnel reform, which is a serious problem for the Science and Mathematics Teachers in primary and middle schools. These problems add to their living stress and challenge them all the time (Ho, 2017). Besides, a new stress for the Science and Mathematics Teachers emerges in this research, which is also a new challenge. The system of appointment of the Science and Mathematics Teachers is featured in job bidding and bottom-out series, which not only puts more stress on their life and mind but also increases the stress of unemployment. In China, the stress from students has been neglected because of the stress from unemployment, examinations and job reputation, which tops the list in the western world (Abel et al., 1999). Things that are beneficial to the Science and Mathematics Teachers’ career growth and professional development, like advanced study, promotion, education background and titles, have been drown in extensive living stress, which should be thought highly of by school leaders and administrative authorities.

The research also indicates that job stress is in direct ratio with job burnout. In some way, it is normal and unavoidable that the Science and Mathematics Teachers suffer from a lot of stress, because practitioners in any industry have to face diverse stress. Therefore, a high level of stress can excessively consume the emotional and physical resources of the Science and Mathematics Teachers and ultimately lead them to a severe state of job burnout (Veldman, van Tartwijk, Brekelmans, & Wubbels, 2013). Shi Shufen made a regression analysis on the job exhaustion of primary and secondary school of the Science and Mathematics Teachers based on background factors, job stress and coping style, and found that the predictive power of job stress was the highest (Shufen, 1990). Lv Xinhua’s research shows that there is a significant positive correlation between stress and job exhaustion of middle school of the Science and Mathematics Teachers (Xiuhua, 1997). According to the study of Shan Xiaolin, stress is the source of high professional exhaustion of the Science and Mathematics Teachers (Xiaolin, 1990). Xu Fuming’s research also shows that there is a significant positive correlation between the stress of primary and secondary school of the Science and Mathematics Teachers and the exhaustion of the Science and Mathematics Teachers (Fuming et al., 2003).

Coping Style and Job Stress

Studies have shown that in addition to personality, Noon-genetic factors, like environment, have an influence on coping style. In coping style, the Science and Mathematics Teachers in nursery schools show the most positive coping styles while the Science and Mathematics Teachers in high schools tend to choose negative coping styles, the reasons for which are various. It may have relevance to such factors as their living background, the level of salary, social position and even how long they have been a teacher in elementary schools. In subjective support, the Science and Mathematics Teachers in middle schools top the list, while the Science and Mathematics Teachers in primary schools comes the last, less than nursery schools. Two reasons lead to the difference of subjective support: One is subjects’ sense of objective social resources and the other is the objective social resources that support the subjects. In curriculum reform, objective support needs to be raised as well as the Science and Mathematics Teachers’ recognition of social support. The study echoes Hassid’s research: The more social support an individual can get the more active he behaves.

When the Science and Mathematics Teachers take measures to cope with stress, relatives and friends in a timely manner economic help, material support, is beneficial to the solution of the stressful events, while moral support can improve the confidence of the Science and Mathematics Teachers, improve their ability to solve problems. At the same time, because the Science and Mathematics Teachers are good at using resources, he can solve problems more efficiently. Finally, the problem of stress is solved better and the possibility of job burnout is greatly reduced. Coping styles have a direct impact on job burnout. Social support affects job burnout through mediation of coping styles, and negative coping styles have larger effect than positive coping styles, at the same time, this study showed that stress source events can also affect the work of social support and coping styles, and the size of the social support that the individual has to feel, affects the adoption of coping styles, thus affecting the individual symptoms of job burnout.

On the other hand, if the Science and Mathematics Teachers' social support level is bad, bad relationships with family, friends very few, in case of urgent problems difficult to get the material and spiritual help, and feel very poor interpersonal relationships, interpersonal communication is also very failure, I don't know how to seek the help of others in need. For him, the onset of stress is the beginning of a nightmare. Short-term stress is gradually becoming a chronic stress, and job burnout is only a matter of time. If the individual is under stress for a long time, his difficulties cannot be resolved, during this period and no buffer resources and support system, the stress will gradually develop into job exhaustion.

Effect of Social Support

In the research of social support, many studies formed 2 main models: the main effect model and the buffer model. Buffer model argues that social support has good cushioning effect on the individual in the stress; and social support can protect the individual from stress events' damaging. The main effect model think that social support has common gain effect, no matter whether the individual is in the face of stress and no matter how individual personality factors are, high social support is always accompanied by good physical and mental condition. The conclusions come from a study of statistics, in the statistics there only appear the main effect of social support for individual physical and mental symptoms, and no interaction between social support and life bad events. Corresponding to above 2 models, the foreign researchers think there're 2 kinds of mechanism how social support works on job burnout: social support acts as independent variable for job burnout; social support acts as the buffer variable.

According to the result of regression analysis in this study, for the primary and secondary school of the Science and Mathematics Teachers, it shows the relations: the more serious the job stress (from payment, self-development, interpersonal relationship, evaluation of one's performance, and so on,) is, the more serious the job burnout is; The higher the level of social support (such as objective support, subjective support and support utilization), the serious the job burnout is; Social support has a moderating effect between job stress and job burnout. Social support can provide a buffer against stress in teaching, interpersonal relationships, competition, and workload, so as to alleviate job burnout. In this process, social support mainly alleviates job burnout by cushioning job security, teaching support and self-development.

How does social support play a role of buffer? Buffer Model answers: after perceiving stress, if he got enough social support, the subject can make re-cognition and re-evaluation on the stress, and suppress adverse reactions from the stress, then actively seek for better adjusting response, so as to reduce or even eliminate symptoms for the stress, eventually to achieve the effect of the buffer. In other words, good social support can cushion the negative consequences of stress; in fact it is the negative consequences whose cumulative effect leads to burnout. Concretely speaking, the Science and Mathematics Teachers in higher levels of social support, have good relationships with family, friends, and can get various economic support and spiritual encouragement when they need. They are satisfied with the interpersonal relationship and social ability also can make good use of social resources. In this way, when they are under stress, the various analyses and Suggestions are made by their family and friends as bystanders to help them view the stress from the positive side and turn the stress into motivation. Relatives and friends' much-needed comfort and motivation, and various support can form the Science and Mathematics Teachers' psychological support system to reduce negative feelings, such as anxiety, depression, frustration, helplessness, better to avoid overeating, smoking, alcohol and other bad behaviors, so as to prevent physical and mental diseases caused by the stress.

CONCLUSION

Job stress refers to too much job responsibility or overworked stress on people, which is the hot topic of the current global job stress. Job stress is not only a powerful driving force, but also a negative factor influencing the working performance and job health (Tomic et al., 2008). The Science and Mathematics Teachers are inevitably working under stress when they are engaged in teaching. Stress is normal, when the stress is too large, to personal physical and mental damage and poor performance, the teacher should pay attention to learn self-regulation, to face the frustration and difficulties in life and work, adjust good state of mind and emotions, learn to self-relief. While paying attention to business study, master some knowledge of mental health care, and reduce job stress by relaxing training, transferring attention and talking with people (Dombrovskis et al., 2011). The Science and Mathematics Teachers should constantly improve their personal cultivation, honing their will quality and enhancing their ability to resist the stress of work.

As a cognitive motivation mechanism, self-efficacy represents the faith of the Science and Mathematics Teachers toward their teaching ability. This factor directly affects how the Science and Mathematics Teachers choose their teaching activities, how they attribute their success or failure to teach, and how they regulate their moods. Therefore, the stress mostly affects job burnout through the intermediary of self-efficacy (Zhao et al. 2014). The problem lies in the intensity of workload. Only overload of work goes against people's health and has a bad influence on the Science and Mathematics Teachers. Western scholars have come to the conclusion that the Science and Mathematics Teachers are under high stress. However, it has been testified that the workload of the Science and Mathematics Teachers in China is heavier than that of the Science and Mathematics Teachers abroad. Nearly three quarters of the Science and Mathematics Teachers in China are reported to be under great stress, while the rate varies from one third to one fourth in western local report. It is easily concluded that the relation between job stress and emotional exhaustion reflects that of job burnout and job stress (Austin et al., 2005). A further study shows that the other two dimensions are only related to the stress from interpersonal relationship and job burnout and emotional exhaustion have a positive correlation with the other factors of job stress, making the relation between job stress and job burnout more complex which we didn't have a clear recognition. This has to deepen into diverse sources of job stress and factors of job burnout.

It is commonly thought that job stress leads to job burnout, which is a causal relationship. Facts show that the relation is much more complicate than it was thought. According to the multiple regression analysis, only one or two factors of job stress has an impact on emotional exhaustion, decreased sense of achievement and depersonalization and all the other factors of job stress are secondary to the stress from interpersonal relationship, which makes it clear that some mediating factors influence the relation between job stress and job burnout and further illustrates that job stress indirectly affects job burnout. This isn't involved in the research. In conclusion, it is necessary to set up a social support system aimed at the Science and Mathematics Teachers in the next curriculum reform to raise the Science and Mathematics Teachers' awareness of subjective social support and encourage them to use social support positively.

The level of subjective support involves 2 factors: first, the objective social resources that actually exist to support the main body; the second is the degree of the subject's perception of objective social resources. In general, factor two is based on factor one, but there is a great difference between them. The "existence" in individual subjectivity can be either "true" or "false". Objectively existing social support, if not fully perceived byte Science and Mathematics Teachers, would be ignored. If the social support that objectively does not exist is perceived subjectively by the teacher, or the social support that is perceived is exaggerated, then there will be the effect: "feeding on fancies, drawing a cake to satisfy hunger". Positive and optimistic state of mind can actually eliminate adverse effects the Science and Mathematics Teachers' job burnout; studies have confirmed that a person no matter belongs to self-reflection and inner awareness, as long as optimistic, their psychological health level is high

From a personal perspective, the Science and Mathematics Teachers should not compare their own efforts, gains and benefits with other people's differences. They should compare themselves with their own ideals. After all, the teaching profession is different from other industries, and it is doomed to have no big, big, red and purple life. We are engaged in a career that requires us to be the embodiment of our value in the growth of our students, which is the personality of the teacher. To this end, we need to have a common heart to see ourselves and see gains and losses in a calm state of mind. Only when you have peace of mind can you face yourself and be practical. You have your life, I have my world, and I am not jealous. Only in this way can I put my heart into my mind and calm down.

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Effects of the Combination of Synchronous Web-Based Teaching with Visually Creative Teaching on Art Students' Creativity

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ABSTRACT

The 21st century is the society of information technology and knowledge-based economy. To cope with the information society, teaching methods would be changed. Traditional chalk and talk can no longer adapt to the changing society. In addition to pass down the tradition, new ideas should also be introduced. In the informational age, the Internet becomes an essential living element and synchronous web-based teaching breaks through the obstacle of space, provides instant and multiple communication channels, and creates alternative creativity learning environment. With experimental design, total 208 students in Fujian University of Technology, as the research objects, are proceeded 15-week (3 hours per week for total 45 hours) experimental teaching. The research results show significant effects of 1.synchronous web-based teaching on creativity, 2.visually creative teaching on creativity, and 3.the combination of synchronous web-based teaching with visually creative teaching on the promotion of creativity. According to the results, suggestions are proposed, expecting to construct courses stressing on interdisciplinary integration and inspiring creativity as well as encouraging students to develop creativity through the "originality" of art.

Keywords: synchronous web-based teaching, visually creative teaching, art, creativity

INTRODUCTION

Innovation and technology do no simply enhance the quality of life, but also drive national economic trend and social development. To outperform on the international stage, it is necessary to cultivate national creativity and transfer excellent abilities of making changes into the token to enhance the international status. Creativity environment is a key in promoting students' technological creativity. In addition to designing appropriate course contents, it is primary to construct learning environment beneficial for the cultivation of creativity. In the informational age, the Internet becomes an essential living element and synchronous web-based teaching breaks through the obstacle of space, provides instant and multiple communication channels, and creates alternative creativity learning environment.

The 21st century is the society of information technology and knowledge-based economy. Changes in teaching methods are required for coping with the information society. Traditional chalk and talk could no longer adapt to the changing society that it is necessary to create new ideas in addition to passing down the tradition.

Along with the development of information technology, the era of global village, and the diversification of society, "creativity" has become the basis of talent development in various countries, which actively cultivate the next-generation creativity to enhance national quality and thicken national competitiveness for developing knowledge-based economy. To pursue living satisfaction, people have to solve old problems with innovative methods or more effectively utilize resources and even develop personal potential to the higher level. Such ideas rely on the cultivation and presentation of creativity. Individual creativity or group creation ability has become the major source of competitiveness of the society or a nation. It is therefore worth of emphasis to enhance creativity. Art is closely related to life. Art educators should match modern information technology, integrate creative ideas into art learning and teaching to cultivate students' independent inquiry and innovative thinking, enhance the life

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Contribution of this paper to the literature

- Group discussion and cooperation could help discover others' different creation and ideas, mutually inspect and evaluate the schedule, and enhance team efficiency and thinking skills with cooperation.
- A teacher should provide more analysis and comparison practice, e.g. team discussion, for students discussing problems and expressing ideas. Or, a teacher could propose open-ended problems and encourage students present the opinions.
- Team creativity contest would be a good choice for students learning teamwork skills and applying learned knowledge to actual problem-solving.

cognition and problem-solving abilities, and further construct courses stressing on interdisciplinary integration and inspiring creativity to encourage students developing creativity through "originality" or art.

LITERATURE REVIEW

Synchronous Web-based Teaching

Synchronous web-based learning, as a learning model "in different place at the same time", utilizes the combination of the Internet and computer-related software and hardware for instructors and learners, who are in different places, proceeding teaching and learning activities at the same time through the functions of instantaneity and two-way communication offered by electronic equipment (Chou, Lunsford, & Thomson, 2015). Under synchronous web-based environment, teachers and students get online at the same time and properly use network synchronization platforms, e.g. audio or video conference, electronic whiteboard, chatroom, and stream media, for real-time interactive learning activity (Molano & Polo, 2015). Interaction is the key in effective learning and information exchange, and the major characteristic of synchronous web-based learning lies in simulating the face-to-face interaction in traditional classrooms through audio and video interaction tools (Cela, Sicilia, & Sánchez, 2015). In synchronous learning, teachers could transmit materials, sound, and images to students through multimedia; meanwhile, teachers could acquire students' audio and video responses. Such presentation with multimedia breaks through the communication with texts, allowing students and teachers, who are in different places, shortening the distance, reducing the sense of loneliness of individual learning, and enhancing learning effect (Jansen, Scherer, & Schroeders, 2015). Ricoy and Feliz (2016) indicated that synchronous web-based teaching, similar to traditional face-to-face learning, was a real-time, lecturer-led online learning pattern, where all learners had to get online learning and communicating at ruled time and the lecturer had to manage the classroom. Xu, Huang, and Tsai (2014) explained the interaction being proceeded through visual classroom, video conference, Internet phone, chatroom, stream media, or two-way broadcasting system. Synchronous web-based learning environment would not be restricted the space as "traditional classrooms" and could save the time and costs for traveling back and forth schools. Yilmaz (2016) described that teachers and students merely combined personal computers and the Internet, at the same time, to effectively apply the tools offered by network synchronization platforms, e.g. chatroom, electronic whiteboard, audio or video conference, and visual classroom, to achieve the high-interaction effect as face-to-face instruction (de-Marcos et al., 2016).

Visually Creative Teaching

Dong, Zhang, Dai, and Guan (2014) indicated that visually creative teaching was integrated into general painting creation and color courses to provide the thinking with creative visual image. Although the goal was to develop visual creativity, the basic training of painting skills and color knowledge could not be neglected. In this case, the grasp of creation modeling and the training of color application in teaching activity should be emphasized. Shadiev, Hwang, Huang, and Liu (2015) mentioned that visual thinking was an ordinary human behavior; visual thinking was required in daily life for either abstract theories or specific entities. When people were at visual thinking, visual and thinking present initiative and purposiveness. Chen (2015) considered that visual thinking could assisting the construction of mental model and the connection with creative thinking. Visual experience could have affairs and objects become explorable and allow learners presenting imagination space to expand the learning depth. Yamada et al. (2016) concluded that "visual thinking" could explain learners' thinking and problem-solving, enhance the comprehension and analysis of complex problems, and promote the expression, communication, and creative thinking abilities through visual elements of pictures, colors, charts, graphs, and fantasy. Katz, Eilot, and Nevo (2014) explained that the creation of visual art covered from internal creation to external creation and from thinking to performance; creators could compose internal intention as well as specifically present imagery that the work was the result of visual creation. Visual creation was to apply the training in creativity to visual performance with visual creativity, present the ability of visual thinking, and transfer idea or emotion into specific color structure with image performance strategies (Pellas, 2014). Clark (2015) referred visually creative teaching to using perceived imagery records for generating images by applying imagination combination in the brain. Mental imagery could be divided into two layers; one was clearness, including the grasp of the image, freshness, and contained details of subjects, and the other was control, as the degree to manipulate thinking image. Park and Lee (2014) pointed out visually creative teaching as applying drafts, graffiti, sketches, or picture writing to record the thinking process or communicate with others. Paining, the communication of thinking imagery, could thoroughly apply visual thinking ability to record, store, manipulate, and communicate imagery.

Creativity

Lai and Chen (2014) regarded creativity as the ability of people with excellent creative performance, i.e. reflecting people's idea of creativity being the intuitive opinion of ability. You (2015) considered that creation was to discover facts, problems, ideas, and acceptable solutions with cognition, imagination, and assessment, i.e. creative problem-solving. García-Saiz, Palazuelos, and Zorrilla (2014) regarded creativity as creators, for special needs or useful purposes, combining connectable elements to become new relationship. Paule-Ruiz et al. (2015) defined creativity as the psychological process to exceed existing experiences in the problem situation, break through habitual limits, and form brand-new concepts as well as the ability to solve problems by flexibly applying experiences, without being limited by rules. Darvin and Norton (2014) argued that creativity could not be simply regarded as personality tendency or ordinary ability, but the integration of personality traits, cognitive ability, and social environment. In this case, problems could be effectively solved by the integration of work motivation, special skills, and creativity related skills. Sheorey (2014) pointed out the characteristics of creative products as unique, goal-definite, and not conflict to or match with other goals, needs, and value of human beings. Hwang, Kongcharoen, and Ghinea (2014) indicated that creativity was an innate ability of an individual; although it appeared individual differences with personal traits, creative thinking ability, under the support of creative environment, could be cultivated and induced creative products through the reflection of creation process; the so-called creative products, regardless of specific products or abstract cognition and emotion, were the presentation of creativity. Paver et al. (2014) also regarded creation as the changing process of an individual or a group as well as the performance of cognition, affection, and will that the performance result allowed oneself, an individual, or the created field changing to a higher level. Creativity normally contained several basic cognitive abilities, including divergent thinking.

Referring to Chen, She, Kameda, and Ohno (2015), three indicators for evaluating individual creativity are applied to this study.

(1) Visual perceptual power: A creative person presents keen observation, could easily see what people ignore, perceive tiny visual sensation, and form more association and imagination.

(2) Word power: A creative person could reinforce the combination between words and mind, understand how to change speaking model, often inspect the relationship between thoughts and speech, relax fixed thinking model, and change habitual thinking and speech to enhance thinking fluency.

(3) Drawing power: Words and characters are the symbols to express information. However, most people simply pay attention to the original meaning of a word, but ignore the message delivered by fonts. A creative person with the ability of painting performance could relax thinking and give a new meaning and performance to a font with painting concepts and patterns.

RESEARCH HYPOTHESIS AND METHOD

Research Hypothesis

Wasim, Sharma, Khan, and Siddiqui (2014) regarded the necessity of supportive environment for people's creativity; without environmental support, the inner source of a person's creativity might not be seen. Hocevar, Flanagin, and Metzger (2014) proposed an effective method to enhance individual or team creative thinking as free association and delayed criticism, releasing personal ideas under pleasant and warm atmosphere, and largely acquire creativity in short period through collective thinking and idea agitation. Under synchronous web-based teaching environment, teachers and students getting online at the same time and well applying network synchronization platforms, e.g. audio or video conference, electronic whiteboard, chatroom, and stream media, to real-time interactive learning activity could effectively enhance students' creativity through collective thinking and idea agitation. Lee (2014) pointed out the importance of "environment" to creativity. The synchronous web-based environment created by synchronous platforms could achieve real-time interaction, as face-to-face, as well as provide multiple and open learning environment with the assistance of platform functions to enhance students' creativity. For this reason, the following hypothesis is proposed in this study.

Table 1. Analysis of Variance of synchronous web-based teaching

Variable		F	P	Scheffe post-hoc
synchronous web-based teaching	visual perceptual power	11.237	0.000**	synchronous web-based teaching>general traditional teaching
	word power	9.685	0.000**	synchronous web-based teaching>general traditional teaching
	drawing power	12.418	0.000**	synchronous web-based teaching>general traditional teaching

* stands for p<0.05 and ** for p<0.01

H1: Synchronous web-based teaching shows significant effects on creativity.

Lindt, Corkin, and Yu (2014) mentioned that creativity was the motive to observe affairs and generate new concepts, and visual art was the activity to execute creativity. The practice of creative teaching should be implemented in visual art education to help implement students' creativity for keen, fluent, changeable, unique, and advanced characters as well as apply such characters to the problem solving and visual concept of visual creation so that the creative performance of visual art could be thoroughly developed (Xu & He, 2014). Huang et al. (2014) indicated that visual pattern was prior to language pattern; the training of visual performance was affirmed by experts to present the function to inspire creativity and was an effective creative thinking teaching strategy that visually inspiring creativity could yield twice the result with half the effort. You (2015) referred sensory as the perception of material world, i.e. the experience saw and recorded in the brain. Observation was the primary element to generate creativity; the clearer observation would result in clearer memory; such memorized images would be stored in the brain for creating new imagery. Accordingly, the following hypotheses are proposed in this study.

H2: Visually creative teaching shows notable effects on creativity.

H3: The combination of synchronous web-based teaching with visually creative teaching reveals remarkable effects on creativity.

Research Object and Research Design

To effectively achieve the research objective and test the research hypotheses, nonequivalent pretest-posttest control group design is applied in this study. Total 208 students in Fujian University of Technology are proceeded the visually creative teaching integrated synchronous web-based teaching 2╳2 experiment. The experiment is grouped into visually creative teaching (visually creative teaching; general traditional teaching) ╳synchronous web-based teaching (synchronous web-based teaching; general traditional teaching) for the 15-week (3hrs per week for total 45 hours) experimental teaching.

Analysis Method

Analysis of Variance is utilized in this study for discussing the effect of synchronous web-based teaching on art students creativity and further understanding the effect of the combination of synchronous web-based teaching with visually creative teaching on art students' creativity.

RESULT AND ANALYSIS

Analysis of Variance of Synchronous Web-based Teaching and Creativity

According to Analysis of Variance, the difference of synchronous web-based teaching in visual perceptual power, word power, and drawing power is discussed. From **Table 1**, synchronous web-based teaching and general traditional teaching present significant differences on visual perceptual power, synchronous web-based teaching revealing higher visual perceptual power than general traditional teaching. Furthermore, synchronous web-based teaching and general traditional teaching show remarkable differences on word power, synchronous web-based teaching appearing higher word power than general traditional teaching. Finally, synchronous web-based teaching and general traditional teaching reveal notable differences on drawing power, synchronous web-based teaching presenting higher drawing power than general traditional teaching. H1 is therefore supported.

Analysis of Variance of Visually Creative Teaching and Creativity

According to Analysis of Variance, the difference of visually creative teaching in visual perceptual power, word power, and drawing power is discussed. From **Table 2**, visually creative teaching and general traditional teaching show significant differences on visual perceptual power, visually creative teaching appearing higher visual perceptual power than general traditional teaching. Moreover, visually creative teaching and general traditional teaching present remarkable differences on word power, visually creative teaching revealing higher word power

Table 2. Analysis of Variance of synchronous web-based teaching

Variable		F	P	Scheffe post-hoc
visually creative teaching	visual perceptual power	13.284	0.000**	visually creative teaching>general traditional teaching
	word power	10.925	0.000**	visually creative teaching>general traditional teaching
	drawing power	15.841	0.000**	visually creative teaching>general traditional teaching

* stands for p<0.05 and ** for p<0.01

Table 3. Analysis of Variance of synchronous web-based teaching on statistical learning effectiveness

Variable	visual perceptual power			word power			drawing power		
	F	P	Scheffe	F	P	Scheffe	F	P	Scheffe
synchronous web-based teaching	11.237	0.000**	Web-based > general	9.685	0.000**	Web-based > general	12.418	0.000**	Web-based > general
visually creative teaching	13.284	0.000**	Visual > general	10.925	0.000**	Visual > general	15.841	0.000**	Visual > general
網路同步*visual creativity	36.583	0.000**	11>21>12>22	42.162	0.000**	11>12>21>22	47.352	0.000**	11>21>12>22

* stands for p<0.05 and ** for p<0.01

than general traditional teaching. Visually creative teaching and general traditional teaching appear notable differences on drawing power, visually creative teaching presenting higher drawing power than general traditional teaching. Apparently, H2 is supported.

Analysis of the Effect of the Combination of Visually Creative Teaching with Synchronous Web-based Teaching

Applying Analysis of Variance to discuss the difference of visually creative teaching integrated synchronous web-based teaching in art students' creativity, Two-way Analysis of Variance is used for discussing the interaction of visually creative teaching and synchronous web-based teaching to test the promotion of visually creative teaching. From Table 3, synchronous web-based teaching integrated visually creative teaching shows the highest learning outcome, and the interaction of synchronous web-based teaching integrated visually creative teaching appear the highest learning gain that H3 and H4 are supported.

CONCLUSION

The research results show the assistance of the combination of visually creative teaching with synchronous web-based teaching in creative tendency. For the application of creative thinking teaching, it should arrange proper situations and environment, apply diverse teaching to give students more response time for creative thinking, provide appreciation and encouragement, respect individual differences, parallelly operate teamwork and independent creation, grasp the basic principle to induce students' creative thinking, well apply synchronous web-based teaching resources, and arrange long-term visually creative teaching course planning in order to appear more significant effects on the affection dimension of creativity. The synchronous web-based learning environment provides favorable individual thinking space to effectively reduce disturbance among classmates. On the other hand, with the assistance of synchronous platforms, students, without directly talking to people face-to-face, feel more comfortable, can more easily speak out the ideas, and are brave to announce personal opinions; and, the teacher-student interaction is enhanced. Synchronous web-based teaching shares sound, pictures, and even films with each other to enrich the learning media. What is more, teachers would be more convenient and fast to deal with materials or handouts or rapidly updating materials and avoiding the loss of handouts.

SUGGESTION

According to the research conclusion, the following suggestions are proposed in this study.

1. It is suggested to apply teamwork and independent creation when applying the combination of visually creative teaching with synchronous web-based teaching to teach art students. Meanwhile, group discussion and cooperation could help discover others' different creation and ideas, mutually inspect and evaluate the schedule, and enhance team efficiency and thinking skills with cooperation. In the art independent creation process, an individual has to integrate collected information and image thoughts for internalization and absorption to generate unique presentation methods. In this case, teaching methods could be flexibly adjusted depending on the situations, and cooperative learning and independent creation allow art students promote the creativity by mutually observing the work.

2. A teacher should provide more analysis and comparison practice, e.g. team discussion, for students discussing problems and expressing ideas. Or, a teacher could propose open-ended problems and encourage students present the opinions, but not criticizing students' opinions, to cultivate students' analysis and comparison abilities. Students with art creativity potential require analysis and judgment abilities to put the ideas into practice.
3. A lot of students show high interests on activity performance, while some students with excellent academic achievement could not connect the learned content. Team creativity contest would be a good choice for students learning teamwork skills and applying learned knowledge to actual problem-solving. Particularly, when the creative activity topic is correlated with students' learning courses, students would have stronger motivation to learn or search for relevant knowledge.

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I am Becoming a Doctor: Mine or Someone Else's Will? Or Does it Even Matter? A Qualitative Investigation

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ABSTRACT

This study explored the motivation of underperforming students at three points of time: applying the programme, studying in Year 1 and during their repeating year due to academic failure. Six underperforming Year 1 students were interviewed on their initial motivations for choosing the medical programme. Triangulation of analysts was applied in the narrative analysis. Later, these students completed the Academic Motivation Scale (AMS) questionnaire twice to reflect on their learning experience in Year 1 and their repeating year. Results showed that these students initially had a mix of amotivation, intrinsic motivation and extrinsic motivation upon applying the medical programme where the worst case scenario was that students genuinely "did not know why". It was further shown that their motivation for studying medicine was unchanged, increased or decreased over a period of time. Although this study fails to support the notion that initial motivation matters in influencing academic success, the AMS results proved that student motivation could also change over time. Hence, more effort is needed to nurture intrinsic motivation after enrolling into medical schools.

Keywords: medical education, underperforming students, motivation, changes of motivation, interview

INTRODUCTION

Motivation is essential for students to succeed in their studies and careers. Initial motivations of students for choosing the medical programme and possible changes of motivation for studying medicine over a period of time are the focuses of the study.

Initial Motivations of Students for Choosing the Medical Programme

Past studies investigated initial motivations of students for choosing the medical programme. We summarised these past findings into types of motivation following the Self-Determination Theory (Deci & Ryan, 2000, 2008; Ryan & Deci, 2000a, 2000b) (**Table 1**). Motivation is a self-determination continuum. There are three types of motivation, namely intrinsic motivation, extrinsic motivation and amotivation. Intrinsic motivation is defined as motivation perceived from within oneself. Three subtypes of intrinsic motivation are the motivation to know, motivation towards accomplishment and motivation to experience stimulation.

Student intrinsic motivation for choosing a medical programme from previous studies includes: (a) altruism (desire to help people, giving back to society), (b) interest in Science/Biology and (c) vocation. Extrinsic motivation is defined as motivation perceived from the external environment or outside of oneself. The four subtypes of extrinsic motivation are external regulation, introjected regulation, identified regulation and integrated regulation. Past studies that have dealt with student extrinsic motivation for choosing a medical programme includes: (a) parents or family expectation/pressure, (b) monetary gain, (c) prestigious profession, (d) good academic results, (e) illness/death in the family, (f) maintaining self-worth and (g) career prospects. Amotivation is defined as having the lack of intention or motivation to do a particular action, where it is neither regulated by external nor internal

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Contribution of this paper to the literature

- To date, the possible changes of motivation for studying medicine over a period of time have been limitedly explored and discussed.
- This study explores the Eastern perspective and discussed the Western versus Eastern contexts.
- This study suggests that student motivation may shift over a period of time, and more effort is required to nurture intrinsic motivation after students enroll into medical schools.

Table 1. Past studies on initial motivations of students for choosing the medical programme

Types of Motivation	
Extrinsic Motivation	**Intrinsic Motivation**
(a) Parents or family expectation/pressure (Al-Hemiary, Al-Nuaimi, Al-Saffar, & Randall, 2017; Diwan, Minj, Chhari, & De Costa, 2013; Rashmi A Kusurkar, Croiset, Galindo-Garré, & Ten Cate, 2013; McHarg, Mattick, & Knight, 2007; Pruthi et al., 2013; Shankar, Singh, Gautam, & Dhaliwal, 2013)	(h) Altruism (desire to help people, giving back to society) (Al-Hemiary et al., 2017; Ayuob et al., 2015; Crossley & Mubarik, 2002; Diwan et al., 2013; Gąsiorowski, Rudowicz, & Safranow, 2015; Girasek et al., 2011; Győrffy et al., 2016; Heikkilä et al., 2015; Hyppölä et al., 1998; Rashmi A Kusurkar et al., 2013; McHarg et al., 2007; McHugh et al., 2011; Molnár, Nyári, Hazag, Csinády, & Molnár, 2008; Pagnin et al., 2013; Pruthi et al., 2013; Puljak, Kraljevic, Latas, & Sapunar, 2007; Skatova & Ferguson, 2014; Vaglum et al., 1999)
(b) Monetary gain (Crossley & Mubarik, 2002; Győrffy, Birkás, & Sándor, 2016; Heikkilä et al., 2015; Hyppölä et al., 1998; Rashmi A Kusurkar et al., 2013; McHarg et al., 2007; McHugh et al., 2011; Skatova & Ferguson, 2014)	(i) Interest in Science/Biology (Crossley & Mubarik, 2002; Gąsiorowski et al., 2015; Girasek et al., 2011; Győrffy et al., 2016; Rashmi A Kusurkar et al., 2013; McHugh et al., 2011; Pagnin et al., 2013; Puljak et al., 2007)
(c) Prestigious profession (Diwan et al., 2013; Girasek, Molnár, Eke, & Szócska, 2011; Győrffy et al., 2016; Heikkilä et al., 2015; Hyppölä et al., 1998; Khami, Murtomaa, Jafarian, Vehkalahti, & Virtanen, 2008; Rashmi A Kusurkar et al., 2013; Skatova & Ferguson, 2014)	(j) Vocation (Al-Hemiary et al., 2017; Heikkilä et al., 2015; Hyppölä et al., 1998)
(d) Good academic results (Vaglum, Wiers-Fenssen, & Ekeberg, 1999)	
(e) Illness/death in the family (Győrffy et al., 2016; Hyppölä et al., 1998; McHarg et al., 2007)	
(f) Maintaining self-worth (Wouters, Croiset, Isik, & Kusurkar, 2017)	
(g) Career prospects (Ayuob, Bahumdain, AL-Najei, Khobrani, & El Deek, 2015; Crossley & Mubarik, 2002; Girasek et al., 2011; Győrffy et al., 2016; Heikkilä et al., 2015; Hyppölä et al., 1998; Pagnin et al., 2013; Skatova & Ferguson, 2014)	

factors. Students' initial motivation that is classified as amotivation for choosing a medical programme was not found in past literature.

Understanding on motivation is essential as motivation influences the educational outcomes of the students, including their perseverance in their studies, academic success, learning behaviour, career satisfaction and career choices (Kusurkar, Ten Cate, van Asperen, & Croiset, 2011). There has been evidence indicating a significant relationship between motivation and academic success (Yousefy, Ghassemi, & Firouznia, 2012) where high intrinsically and high extrinsically motivated students performed significantly better than those with lower motivations (Shrestha & Pant, 2018). Although there has been a number of studies on this matter, there have been null studies in the Malaysian context in the past ten years (Goel, Angeli, Dhirar, Singla, & Ruwaard, 2018).

Three decades ago, two quantitative studies identified the main initial motivations among Malaysian students, which were genuine interest and the desire to help people (Parameshvaradeva, 1981; Shahabuddin, 1986). An unhealthy trend emerged later in 1996 where it was revealed that some students chose the medical programme due to family influence and monetary gains (Razali, 1996). Consequently, the same study also reported that 19% of clinical students thought it was the wrong choice for choosing the medical programme. Despite this, there is still a continuation in the unhealthy trend of choosing the medical profession for extrinsic reasons. In a country where the medical profession is seen as highly prestigious in society (Cruez, 2014; Lee, Foong, Choon, & Jamuna, in press; Yusoff, Rahim, Baba, & Esa, 2011), provides job security and pays well, these are promising incentives.

Furthermore, with more medical doctors reluctant to work in rural areas, researching into motivation is essential as motivated doctors would have more enthusiasm in putting forth and initiating efforts to improve the healthcare services in the country (Goel et al., 2018). Developing countries such as Malaysia would encounter more severe inequitable distribution of doctors between the urban and rural areas, where one of the reasons is most likely due to poor motivation (Hurst, 2014). Multiple public discourses in the media have addressed this matter and it was postulated that lack of interest and passion are the main reasons doctors are quitting their housemanship (i.e., two-years training programme after graduation, otherwise known as internship or foundation in some countries), mainly due to their initial motivation in fulfilling parents' expectations. However, there is still a lack of research evidence to back up or refute this belief. Although there have been past studies in other countries which question the motivation of students applying to study medicine, it was found that results vary across different countries or cultures (Woodward, Thomas, Jalloh, Rees, & Leather, 2017), thus further cementing the need to carry out this study.

Therefore, in the Malaysian context, this study would like to answer the following research questions: What were the initial motivations of Year 1 underperforming students for choosing the medical programme? Were they intrinsically motivated? To the best of our knowledge, we may represent the first qualitative study investigating initial motivations of underperforming medical students in Asia.

Possible Changes of Motivation for Studying Medicine over a Period of Time

Table 1 clearly indicates that students it is unnecessary for students to be intrinsically motivated to become medical doctors. Since intrinsic motivation to study medicine helps students to appreciate their profession and increase their career satisfaction, we are concerned if the motivation to study medicine would be dynamic and fluctuating. Is there a possibility motivation to study medicine can change? Such argument is important because if motivation could change over a period of time, intrinsic motivation could be nurtured to promote deep learning, better academic performance and positive well-being (Kusurkar et al., 2011). To date, possible changes of motivation for studying medicine over time have been limitedly explored and discussed (An et al., 2017). Del-Ben et al. (2013) attempted to answer this question. Discouragingly, their findings showed that motivation of Year 1 students reduced throughout their academic year.

It should also be noted that motivation is a process and a continuum where amotivation or extrinsic motivation could develop into intrinsic motivation or vice versa (Feri, Soemantri, & Jusuf, 2016; Ryan & Deci, 2000). Therefore, this study would like to answer the following research questions: How was the motivation of Year 1 underperforming students during their first attempt (studying in Year 1) and their second attempt (during their repeating year)? Did their motivation change?

METHODOLOGY

Context of the Study

Qualitative studies allow meaning to emerge from the data. The initial plan of a larger study that we conducted was to explore the possible causes of academic failure among underperforming medical students. However, as this larger study progressed, initial motivations of students for choosing the medical programme had caught our attention as there was a mix of genuine and non-genuine motivations. As these underperforming students were repeating Year 1, we also monitored their motivation to study medicine as a part of an intervention. We are remedial coaches for student support in the medical programme. We have medical or education qualifications, and we have received training in conducting education research.

Prior to their admission to this medical school, these underperforming students had scored the maximum cumulative grade point average at their pre-university level and performed satisfactorily in the admission interview. After enrolling into this medical school, they were engaged in an integrated curriculum in which Year 1 consists of Language in Medicine, Foundation of Medical Sciences, Musculoskeletal Sciences, Cardiovascular Sciences and Respiratory Sciences. Students were required to participate in weekly problem-based learning sessions and clinical exposures. At the end of Year 1, these students were unable to perform satisfactorily in all assessments, where they either failed the knowledge or clinical assessments, or both. Upon repeating Year 1 (i.e. second attempt), they were required to undergo all the teaching and learning sessions and assessments once again the following year.

Target population of the study was all underperforming medical students who were repeating Year 1 in our institution. In the academic session 2016/2017, there were six underperforming students who failed their Year 1 studies (i.e. first attempt) and they were required to repeat the year (i.e. second attempt). All six underperforming students consented to participate in the study where the sample was the population. Meanwhile, in this case study, these informants represented typical cases of underperforming students where obtaining their experiences would be informative in comprehending other underperforming students in our institutions, which share similarities with the context of this study (Yin, 2003).

Procedures of Data Collection

Ethical approval was obtained from the institution. We conducted a meeting with all Year 1 underperforming students at the beginning of their repeating year. These students had been in the medical programme for one year, but we did not have any prior personal relationship established with them. In the meeting, students were explained on the purpose, possible benefits and ethics of this study. Their participation was completely voluntary and they were allowed to withdraw at any time. It was also explained to the students that their honest responses in the interviews and questionnaires would not affect their future academic results. Using this data, they were to be guided to reflect on their initial motivations for choosing the medical programme and possible causes of their academic failure. These efforts were expected to encourage students in expressing their honest responses and the students were reassured on the ethics of the present study.

Upon obtaining the signed written consents, an interview was scheduled for students individually. Results from the interviews informed of the motivation of the underperforming students at the time of applying to the medical programme. At times, using interviews are the only way to get hold of data to explain a particular phenomenon and is "necessary when we cannot observe behaviour, feelings or how people interpret the world around them" (Merriam, 2009). The interview was semi-structured and the same question was asked to each student at the beginning of the interview: "Why did you choose to study medicine?" in order to better comprehend their initial motivations for choosing the medical programme. Following the initial questions, students were challenged or prompted on their responses for choosing medicine such as "You wanted to help people. But nurses help other people as well. So, why did you not choose to become a nurse?" From here, more questions were asked for probing based on the answers given by the students. The interview questions were piloted with under perfoming students from the previous academic session. Each interview lasted approximately 60 to 90 minutes and it was audio-recorded. The first author conducted the interviews. The interviews were conducted in an interview room with minimal disruption from noise and people, so that the students felt safe to share. No repeat interview was conducted.

In medical schools, the Academic Motivation Scale (AMS) was used to compare students' motivation over a period of time (Del-Ben et al., 2013). In this study, the underperforming students completed the AMS questionnaire where they were asked to reflect on their motivation for studying in Year 1. Six months later, we conducted another meeting to monitor the well-being and progress of these students. At this time, they completed the AMS questionnaire for the second time to report on their motivation during the repeat year (i.e. second attempt). AMS is a validated questionnaire first developed by Vallerand and colleagues in 1989 (Schutte et al., 2017) and is based on the conceptual framework of the Self-Determination Theory (Deci & Ryan, 2000, 2008; Ryan & Deci, 2000a, 2000b). This instrument consists of 28 items scored on a 7-point Likert scale (Vallerand et al., 1992, 1993).

Analysis of Data

Each interview was transcribed verbatim. Two data analysts analysed the interviews and a narrative analysis approach (Riessman, 2005) was used where we applied the use of 're-storying' which are stories from the students, presented in the researchers' own words. There was also a general process to identify an attribute for a portion of the data according to their initial motivation to study medicine. Subsequently, codes such as "monetary gain" and "illness in the family" were created and as similarities were identified, these two codes were categorized under the category of intrinsic motivation, extrinsic motivation and amotivation, as per guided by the Self-Determination Theory.

To further comprehend motivation of these underperforming students to study medicine after enrolling to this medical school, a comparison of their AMS results before and after six months were made. Radar charts were used to clearly illustrate the possible changes of motivation of these students over a period of time.

RESULTS

Initial Motivations of Students for Choosing the Medical Programme

In the present study, there were three male and three female Year 1 underperforming medical students. These students were given female pseudonyms of Alice, Bella, Catherine, Diana, Elizabeth and Fiona to prevent identifiable data.

Alice

Alice is a 19 year old student. The interview began with the question, "Why did you choose to study medicine?" Alice first mentioned of her personal experiences. Alice had always been afraid of clinics and hospitals when she was a young girl. However, she met a kind doctor who was involved in her operation and this doctor eventually inspired her to pursue a career in the field of medicine.

> *"He [the doctor] was actually encouraging me not to worry about the operation and all that stuff. So one of the reasons that encouraged (me) to enroll into medical school was him." (A, Line 6, Interview)*

Alice also expressed her desire to help people. She mentioned that she has "a high affinity towards helping people" (A, Line 40, Interview) and that she cares "too much for people." (A, Line 40, Interview) Coupled with her father having psoriasis, she decided to pursue the medical field even more as she wishes to help her father get better and help as many people as she can in the process.

Although Alice sounded confident with her answers at the beginning of the interview, when pressed for further clarification, she seemed to be unsure of her answers and altered some of the points she said earlier.

> *"…my father said go take medicine. So I took medicine." (A, Line 86, Interview)*

With her father being a dominant figure in the family and having a close rapport with Alice, she mentioned of her father's wish for her to take medicine in university. Without an ambition of her own, taking medicine for Alice seemed like a path she should take.

Bella

Bella is a 19 year old student. When asked on her reasons on why she chose medicine, Bella stated firstly of her deep affinity for helping people "who are in need" (B, Line 2, Interview). She has "seen people suffering" (B, Line 2, Interview) and she wants "to help them (B, Line 2, Interview). Her desire to help people helped influence her to take up the medical programme. Besides that, her grandmother was also suffering and she "really wanted to help" (B, Line 2, Interview). Again, similar to Alice, from all the experiences that she has seen around her, mostly of her family members, has initiated her to take up the medical programme as well.

> *"I usually used to be a very weak student. That's how people see me. I didn't get any importance or people used to degrade me. Like, "You can't do anything. You're just going to be like that the whole of your life. You can't achieve anything." So I decided I should aim really high, to achieve something that people think is impossible. So I chose medicine." (B, Line 2, Interview).*

From the excerpt above, people underestimated her abilities and talents during her school days and saying she would not be capable of doing anything. Tired of being judged and to prove people wrong, she decided to pursue medicine as she "really wanted to do something that is impossible" (B, Line 12, Interview). For Bella, to get into the medical programme at the most prestigious university in the country will silence her doubters and also prove to herself that she can do anything. The more people demotivated her into taking the medical programme, the more she wanted to take the programme.

> *"I want to challenge myself actually. I really wanted to do something that is impossible. At that time, I think almost everyone, when I said I wanted to do medicine, they'll be like "Are you sure you're going to get medicine in a medical school? Are you sure?" Something like that. And then they'll ask me, like University Y [the author's institution], are you sure? It's really hard for a student to get into University Y, like it's an impossible story." So every day I tried to aim for that. I will think I will be in University Y. I am going to be in the medical school in University Y." (B, Line 12, Interview)*

> *"...I said, I wanted to be a doctor. Even they said "It's very costly. I think I can't support you to do that". After that I heard from some of my seniors that I can go for these public universities under any scholarships, something like that. At that time, I really wanted to go and aim high. Every day I worked for that." (B, Line 18, Interview)*

Other than the main reasons, she also said she pursued medicine because she wanted "to be rich" (B, Line 2, Interview), make her "parents proud" (B, Line 2, Interview) and use the medical programme as a platform for self-improvement, which is "to be better in the future" (B, Line 384, Interview).

Catherine

Catherine is a 19 year old student. Personal experience from when Catherine was in her school days influenced her to pursue a career in medicine. She spoke of one of these experiences when she joined the Red Crescent Society in her secondary school.

> *"So I got to know that it isn't always about ourselves. Life is not only about us but also the people around us and how we accept them in our lives. So when I met (these) people, I felt very responsible. I felt a sense of belonging with them. So I was actually interested in giving psychological advice to them. Then when I started learning about first aid and all like that, I attended some cardio-pulmonary resuscitation and basic advanced cardiac life support skills before this." (C, Line 6, Interview)*

It seems that Catherine loves caring for people and is taken by the act of helping those who are sick and hurt. She enjoys and takes interest in helping people and this leads her to want to explore the medical field in more depth.

> *"I have an objective before I entered this medical school. I wanted to become a surgeon or a researcher. I wanted to find at least a cure for this, the most common disease my family members had were [Disease X and Y]. And my grandfather had [Disease Z] and he passed away. So I thought I can find a cure for [Disease Z] or [Disease Y] disease." (C, Line 22, Interview)*

As many of her family members suffer from Diseases Y and Z, especially with her father being diagnosed with Disease Y after her matriculation, she was determined to find a cure for these diseases. As she cannot bear to see her family members and other people suffering, she was determined to work hard in the medical programme and to find these cures.

Diana

Diana is a 19 year old student. Diana seemed to be very indifferent on her initial motivation for choosing medical programme as she simply wants "to give a try" (D, Line 16, Interview). She does not seem to have the passion that she could base her personal experiences and ambitions on in the line of medicine. For Diana, whichever programme she takes, she will be able to do it, and the passion will come later.

> *"It doesn't matter. Whatever course it is, if you study well, the passion will come by itself, along with your interest. I believe in that." (D, Line 26, Interview)*

Diana was aware of the other programmes available to her only after she enrolled into medicine. Taking the medical programme was more of a matter of an opportunity to take advantage of getting good grades in her pre-university education.

> *"When I am already in the medical field, I just realized that I can take other courses. There are (actually) many other courses. Not just medicine." (D, Line 22, Interview)*

Elizabeth

Elizabeth is a 19 year old student. Elizabeth's father was highly influential in her daughter's decision making on picking a "good" profession. Her father suggested that Elizabeth should take the medical programme as it is a "good" programme for her. For Elizabeth, it does not matter whatever programme she chooses in university, as long as she makes her father happy, then she will be happy.

> *"Becoming a doctor is good, and then he really hopes that I can pursue my study in this medicine (programme). And what makes my dad happy, makes me happy. So I chose medicine because it makes me happy." (E, Line 2, Interview)*

Elizabeth also mentioned how she was only exposed to two well-known university programmes which are medicine and engineering. Hence, with the backing and advice from her father, she chose one of the only programmes she knew that will make her father proud.

> *"…because what I was exposed to was just doctor, engineer and nothing else. And I just know these few fields that I might choose for my next study." (E, Line 10, Interview)*

Fiona

Fiona is a 19 year old student. She did not know why she had chosen medicine; she just argued that others such as accounting, finance and business were not suitable for her.

> *"Actually even I also don't know why I'm choosing medicine. Because I can't choose other course because I don't think other course is suitable for me like accounting, finance, business. I chose medicine*

because there is no other course that I can choose. Maybe (it's) just because of this." (F, Line 2, Interview)

Fiona performed well in Biology and enjoyed the subject. Thinking that Biology is related to medicine, Fiona later found it to be untrue. Medical study was different and more difficult from what she had imagined.

> *"…I really thought that Biology is really related to medicine. That's why I chose medicine. Because my Biology is I think for me is okay. But when I come through this year, I felt like yes, it's true. Biology (is) actually a little related to medicine only. Everything is different. Like Biology you study blood, everything is like superficial. But when it comes to medicine, it really considers many issues like, besides the knowledge, you (also) need to know how to deal with patients." (F, Line 12, Interview)*

Fiona was also heavily influenced by her friend's opinions and advice. Her friend convinced her that medicine is a better programme than pharmacy. Hence, she agreed and eventually took up medicine even though at first she wanted to take up pharmacy.

> *"Actually at first, I tried to choose pharmacy. But my friend is choosing medicine. So every time when I have a meal with her, she will tell me, (trying to) convince me. Why (did) you choose pharmacy? She will give her reasons such as "do you want to deal with medicines every day or do you want to deal with real people every day? You can see many different people in the hospital like that" So lastly, maybe the peer influence, I choose the medicine." (F, Line 14 Interview)*

Summary

Three observations can be made out of these six narrative analyses. These underperforming students either had no genuine interest in medicine (i.e. Diana, Elizabeth, Fiona), a mix of genuine interests and other motives (i.e. Alice, Bella), or had genuine interests in medicine (i.e. Catherine). Therefore, initial motivations of underperforming students for choosing the medical programme were either genuine, non-genuine or a mixture of both.

Possible Changes of Motivation for Studying Medicine over a Period of Time

The following radar charts (**Figure 1**) illustrate the changes in AMS scores before and after an interval of six months. The changes in AMS scores exhibit their possible changes of motivation over a period of time (**Table 2**). Three possibilities were identified. Firstly, it is possible that motivation for studying medicine can be similar. Elizabeth had similar levels of intrinsic motivation, extrinsic motivation and amotivation during the first attempt as well as in her second attempt. Secondly, extrinsic and intrinsic motivation of studying medicine could increase. For instance, Alice and Bella had higher extrinsic and intrinsic motivation during their second attempts respectively. Thirdly, motivation for studying medicine could decrease over time. Fiona was shown to have lower intrinsic and extrinsic motivation (and higher amotivation) during the second attempt. In conclusion, motivation for studying medicine may change during their study period.

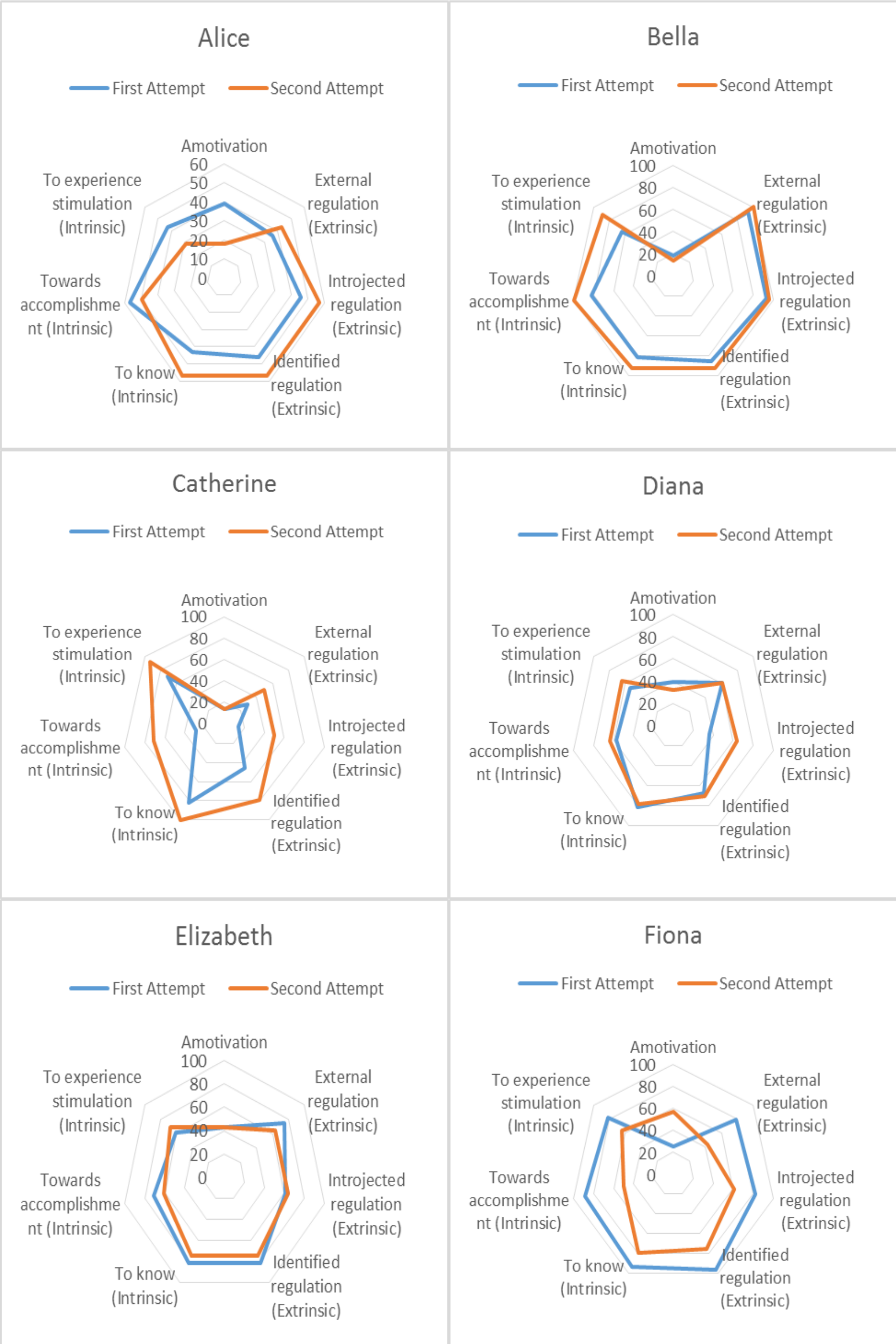

Figure 1. Changes in AMS scores before and after an interval of six months

Table 2. Possible changes of motivation over a period of time

No	Student	Changes
1	Alice	Extrinsic motivation increased Amotivation decreased
2	Bella	Intrinsic motivation increased
3	Catherine	Intrinsic motivation increased Extrinsic motivation increased
4	Diana	Similar level of motivations
5	Elizabeth	Similar level of motivations
6	Fiona	Intrinsic motivation decreased Extrinsic motivation decreased Amotivation increased

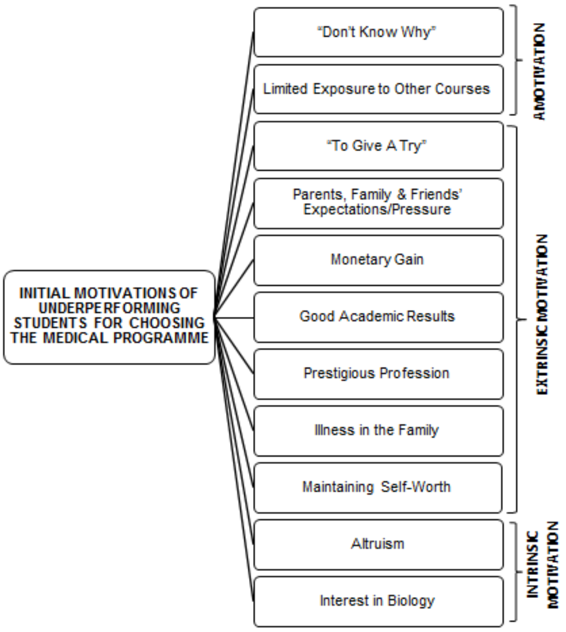

Figure 2. Categorising initial motivations for choosing the medical programme following the Self-Determination Theory

DISCUSSION

Initial Motivations of Students for Choosing the Medical Programme

We categorised initial motivations of the underperforming students for choosing the medical programme into intrinsic motivation, extrinsic motivation and amotivation. Comparison between the findings of this study (**Figure 2**) and past studies (**Table 1**) suggests similarities where there exist intrinsic motivation and extrinsic motivation among the students. Specific similarities include underperforming students who possessed extrinsic motivation such as parents or family expectation/pressure, monetary gain, prestigious profession, good academic results, illness/death in the family and maintaining one's self-worth. The underperforming students also had intrinsic motivation such as altruism and interest in Science/Biology. Initial motivations such as career prospects and vocation were not found and it seems to be reasonable because this study represents a qualitative study with merely six underperforming students.

Findings of this study suggest that postulations made by the Malaysian public (as reported earlier in the introduction) may indeed be true. In this study, some students such as Alice mentioned that her father said to "*go take medicine. So I took medicine.*", whereas Elizabeth said "*…he really hopes that I can pursue my study in this medicine (programme). And what makes my dad happy, makes me happy.*" indicating one of the aforementioned reasons which are the parents' expectations or pressures. This suggests a cultural difference between the Eastern and Western countries. While family pressure is likely to be more common among medical students in Eastern countries (Al-Hemiary et al., 2017), Western studies discovered more genuine interests (Gąsiorowski et al., 2015; Millan et al., 2005). A likely explanation would be due to the cultural differences where it is a norm for Eastern children to show respect by obeying their parents in most life choices (Abdullah & Pederson, 2003; Shin, Lee, & Ha, 2017).

Further explanation is that people from different cultures have varying construals (e.g., perception, understanding or interpretations) of self, others and the dependence between these two variables. Interestingly, these construals can influence an individual's motivation, emotion and cognition (Markus & Kitayama, 1991) and these differences have been observed in the self-construal of people in the East and West (Kitayama, Markus, Matsumoto, & Norasakkunkit, 1997). It has been opined that Western people are more geared towards individualism (independent self-construal) which focuses on personal success and are motivated in expressing themselves (Nishimura & Sakurai, 2017). In comparison, Eastern people have dependent self-construals (collectivism) where they are keen to achieve goals that are shared with others in their social contexts. This is conformed by Bao & Lam (2008) where Chinese children were motivated to do the tasks or goals chosen by parents as they felt related or attached to their parents. When one of the basic human psychological needs (i.e., relatedness) is fulfilled, children are able to internalise their parents' choice as their own choice (Bao & Lam, 2008). Subsequently, they are intrinsically motivated to do the tasks.

On the contrary, our study also identified amotivation as one of the initial motivations for choosing the medical programme. Firstly, some of the students admitted that they were unsure which career pathway to undertake after completing their pre-university education. Secondly, they had limited exposure to university programmes available to them. It seemed either they had not taken the sufficient initiatives to explore career opportunities or career guidance was lacking in their schools. This study is also unique in a sense that the results reported cases of underperforming students admitting they had amotivation when applying to the medical school. Our findings may imply that in order to curb these issues, it is recommended that the national education system could facilitate the transition process from high school to university. Career guidance is essential in creating awareness on the demanding nature of the medical programme (e.g. heavy workload and highly stressful environment) and faculty members can meet and educate high school students to have dialogues on the medical programme and its career life (Juma, Abas, & Banu, 2016). These visits may prepare students for the crux of becoming a medical doctor which emphasizes on intrinsic motivation (i.e. self-directed learning and lifelong learning).

It is generally recognised that intrinsic motivation would positively influence the academic performance of the student (Kusurkar et al., 2011; Shrestha & Pant, 2018; ten Cate, Kusurkar, & Williams, 2011). However, the argument is inconclusive for this study. Even with intrinsic motivation prior to medical school, Bella still underperformed. We ruled out cognitive inabilities of the student as an explanation as these students were selected based on their prior excellent academic results. Hence, this proves that students' initial motivation to choose the medical programme may not matter after all, as all students have been interviewed for the admission selection.

Initial motivations of students for studying medicine are widely used by medical schools as one of the criteria in which the interviewers try to identify during admission (Wouters, Bakker, van Wijk, Croiset, & Kusurkar, 2014). It is generally expected for admission interviews to ask questions such as "Why do you want to become a doctor?' or in other varied manners, 'what experiences have you had that has lead you to believe you would be a good doctor?' to potential candidates in order to select the most intrinsically motivated (Eva, Rosenfeld, Reiter, & Norman, 2004). As medical schools are unlikely to offer a place to candidates who possess low intrinsic motivation, candidates would be expected to give favourable answers to the interviewers (Wouters, Croiset, Galindo-Garre, & Kusurkar, 2016). Internet search engines such as Google, Yahoo! and Bing have a collection of interview techniques and commonly asked questions for candidates to practice beforehand, and these candidates would be able to feign having intrinsic motivation. On the 11 April 2018, Google returned 1,210,000 results on the search terms "medical school interview tips". However, this poses challenges in differentiating candidates who truly possess intrinsic motivation from those who are merely pretending to possess one during the admission interviews. There is also a worry that a candidate's intrinsic motivation to study medicine could be inspired by the demanding selection procedures (e.g. cognitive test, interview) which only temporarily increase his or her motivation (Wouters et al., 2016).

Possible Changes of Motivation for Studying Medicine over a Period of Time

We still argue motivation is important, and our findings suggest that motivation could increase or decrease. As motivation is dynamic and fluctuating in nature, it could be moulded through enhancing student autonomy, competence and relatedness, which are the basic psychological needs for intrinsic motivation according to the Self-Determination Theory (Kusurkar et al., 2011). Motivation is also affected by four factors: situation (alludes to the environmental factors surrounding the individual), mood (emotional state), goal (purpose and targets) and tool (what one needs to possess in order to achieve the goal that has been set) (Yousefy et al., 2012). Meanwhile, strategies to promote motivation could be developed using the concepts of self-efficacy (e.g., mastery, competence, confidence) (Bandura, 1977) and self-regulated learning (e.g. strategy use) (Pintrich & De Groot, 1990).

It is recommended that students themselves as well as the educators should be involved in modifying motivation among medical students. Burnout among medical students has been commonly reported as pursuing a medical degree is known to be highly stressful (Almeida, Souza, Almeida, Almeida, & Almeida, 2016; Cohen et al., 2005; Győrffy et al., 2016; Lyndon et al., 2017; Pagnin et al., 2013; Park et al., 2012). Therefore, after entering medical school, it is imperative for students to properly reflect on why they want to become a doctor, and if possible, they should possess strong motivation. This is so that medical students could cope better with the various challenges awaiting them in their studies (Győrffy et al., 2016).

Though some may argue that students should have known the answer to 'Why do I want to become a doctor?' before applying to medical school, it may not be practical. Students are unlikely to have been exposed to the exhausting nature of the programme before enrolling into the medical schools. Furthermore, misleading images of the medical profession are often found in television medical dramas (Czarny, Faden, & Sugarman, 2010; Strauman & Goodier, 2008). In one study, half of the high school students were observed to be strongly influenced by TV medical dramas to pursue a medical programme (McHugh et al., 2011). These medical dramas often romanticise the true nature of the job such as the heavy workloads and working in a highly stressful environment, thus, further leading to more misconceptions on the reality of the medical profession.

As mentioned, medical educators also play a role. Although students should be mainly responsible for their decisions as adults, medical educators also hold social responsibilities in producing committed and passionate doctors. This effort is important as competencies of medical graduates also encompass the affective domains in addition to the cognitive and psychomotor domains. Hence, focusing on how motivation could develop and why it changes are more meaningful for medical educators in fostering motivation in education (Turner & Patrick, 2008). One of the approaches is to exercise the use of a reflective portfolio. This exercise helps medical students to construct their professional identity and enables the growth of motivation to study medicine (Wong & Trollope-Kumar, 2014). On the other hand, recent findings also showed that early clinical exposure increased motivation to study medicine among the students (Govindarajan et al., 2017; Nimkuntod, Kaewpitoon, Uengarporn, Ratanakeereepun, & Tongdee, 2015)

Medical schools are responsible to create a conducive education environment and there should be a good support system for students who get stressed or demotivated (Roff et al., 1997). Researching into motivation was not only to profile students' motivation, but alerting the medical teachers, their educational roles include to facilitate and manage students with a wider understanding of education theories (Sobral, 2004).

Strengths and Limitations of the Study

Qualitative studies regarding student motivation in pursuing medicine are available, (McHarg et al., 2007; Wouters et al., 2014, 2017) but limited. Furthermore, this present study may be one of the very few qualitative studies that investigates both, the initial motivation and changes of motivations over a period of time of underperforming medical students as they are a minority group. Hence, these students would need greater help in remediating themselves.

There were methodological considerations. Firstly, in the data collection processes, dialogues with students on the benefits (i.e., reflection) they received as well as the management of the confidentiality seemed to yield honest and rich information. Triangulation of analysts, audit trails and describing the context of the study also helped to enhance the trustworthiness of the findings. Secondly, we understand that as remedial coaches for the student support, we may be biased towards these students. An example of this would be making an assumption that underperforming students are lazy and asked leading questions. We encouraged students to honestly express themselves. Thirdly, all Year 1 underperforming students were interviewed. During the interview, we asked the same questions differently (e.g., why did you choose to study medicine? Some students said they choose medicine because they scored excellent results in the pre-university) and we prompted the students following their initial responses. Hence, it was argued that the data is rich and descriptive. Lastly, the students did not check the interview transcripts and findings and we understand that this was a limitation. However, the interviews were transcribed verbatim.

One of our limitations was how some of the data were collected retrospectively. For instance, interviews on students' initial motivation for choosing the medical programme were conducted only after they failed Year 1, which could be questionable. However, data collection upon entering the medical school may also be questionable as students may want to portray a positive image in front of the interviewers instead of revealing they possessed no motivation or were extrinsically motivated. Although data was collected retrospectively, we managed to build rapport and trust with the underperforming students where we believed that they had given an honest reflection of themselves. Besides that, this present study did not investigate the possibility that high performing students may also have amotivation and/or low intrinsic motivation to study medicine. Therefore, future qualitative studies should consider comparing the motivation between high performing and underperforming students to investigate how and why motivations for choosing medicine have influenced their learning experiences. Lastly, large scale quantitative studies to measure changes in motivation to study medicine over a period of time would help to backup (otherwise rebut) our qualitative findings that the changes in motivation are possible.

CONCLUSION

This study revealed that initial motivations of underperforming students for choosing the medical programme may not matter to their academic failures. On the other hand, we still argue that student motivation is important. We believe that genuine interest in medicine should be innate among all medical students and medical practitioners alike. Hence, with the newfound results of this study where a shift in student motivation is possible through a period of time, greater efforts to nurture intrinsic motivation among students should be encouraged in medical schools.

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Effects of the Application of Computer Network Technology to Guided Discovery Teaching on Learning Achievement and Outcome

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ABSTRACT
The development of computer and information technology has human society enter a brand-new information era. The most obvious change is that information becomes inevitable living focus in human life. The promotion of education reform in the world also has information education present the important status, expecting to train students' capability to grasp information and enhance the learning outcome with information technology. Eventually, they could learn the survival skills in the information society as well as promote national competitiveness. With quasi-experimental study, 252 students in Harbin Institute of Technology are proceeded 16-week (3hr per week for total 48 hours) experimental teaching. The research results show that 1.guided discovery teaching would affect learning achievement, 2.guided discovery teaching would influence learning outcome, 3.learning achievement presents significantly positive effects on learning effect in learning outcome, and 4.learning achievement shows remarkably positive effects on learning gain in learning outcome. Finally, suggestions, according to the results, are proposed, expecting to provide thinking methods and direction for students' learning, encourage students to make deeper thinking, and help students establish learning achievement in the principle discovery process to enhance learning efficiency through the practice of computer network technology in guided discovery teaching.

Keywords: computer network technology, guided discovery teaching, learning achievement, learning outcome

INTRODUCTION

The development of computer and information technology in the end of 20th century has human society enter a brand-new information era. Countries in the world made various plans to grasp high technology and acquire advantage on national literacy in order to develop the national power. In the information society, the advance of network communication and information in every level of life allows people interacting with each other through networks and computers for instantaneously and conveniently acquiring required information. The development of technology has human-computer communication become more easily that man-computer interface changes from keyboard, mouse, screen touch, to voice control. Information provided by computers is not simply restricted to texts, graphs, audio and video, but even 3D effect; the visual reality becomes more lifelike and popular. When education reform is promoted in the world, information education also presents the important status, expecting to train students' capability to grasp information with information technology to help them enhance learning outcome and learn the survival skills in the information society as well as promote national competitiveness.

To have students adapt to the complex modern society, educators promote various effective learning strategies, and discovery teaching promoted by educators could cultivate learners to discover, inquire, and solve problems, through discovery or creative learning, as well as independent thinking and creation & invention abilities. Students

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Contribution of this paper to the literature

- Teachers are suggested to analyze the contents of teaching units, list important concepts, and then inquire common teaching experiments or activity about the concepts.
- In consideration of student gap in the same class, teachers are suggested to apply cooperative learning to guided discovery teaching, group students heterogeneously, and have classmates with better degree assist those with bad degree in the learning.
- When teachers intend to change the teaching to be construct-oriented, they need the evaluation tool which could authentically reflect students' knowledge construction ability.

could actively and positively participate in the learning process and self-organize and construct knowledge. In other words, all knowledge is actively manipulated and interpreted by individuals, rather than passively acquiring knowledge. Accordingly, teachers being able to guide students, through problems, to make correct think and control the entire teaching situation to reduce mistake would reduce students' frustration caused by failure. This study therefore applied computer network technology to guided discovery teaching, aiming to provide students with learning thinking methods and direction, through the guidance of problems and peer interaction, encourage students making deeper thinking, help students establish learning achievement in the principle discovery process, and enhance the learning efficiency to further achieve learning transfer.

LITERATURE REVIEW

Web-based Computer Instruction

He et al. (2015) referred computer education to the education focusing on computers as the teaching tool or teaching computer skills; the coverage of information education was broader, including information processing concepts and methods as well as equipment related to computers. Mullis and Martin (2015) regarded computer-assisted instruction or computer-assisted learning as teaching or learning with computers as the tool or medium. Personal computers used to be used for the practice, while assisted teaching and assisted learning in computer labs became popular after the emergence of regional network technology. Chua et al. (2015) indicated that the Internet showed far-reaching characteristics and rich resources, which could induce education scholars and educators utilizing the tools for supporting computer-assisted instruction and learning systems, i.e. distance teaching/learning. Huang, Chang, and Wu (2015) explained web-based instruction as applying the hypermedia and multimedia of World Wide Web (WWW) to create meaningful learning environment so as to enhance or assist in learning, aiming to cultivate learners' automatic learning habit. Borghese et al. (2015) positioned web-based learning as to proceed "teaching" and "learning", the two-way communication teaching, with various advantages of networks. Wu et al. (2016) considered web-based instruction as teachers and students being able to precede teaching preparation, practice teaching activity, evaluating and guidance in the Internet teaching environment. Although web-based teaching environment did not show traditional teaching structure, it presented infinite e-learning space and contained rich e-libraries and increasing useful electronic data. Dolgin (2015) proposed that, in addition to text model, World Wide Web also presented multimedia of graphs and sound to attract most people to development on it. Nonetheless, even though there were lots of mature distance learning websites for interactive functions of material interpretation, assignment hand-in, achievement enquiry, billboards, and discussion, distance learning websites were still designed according to traditional teaching model. Xiong et al. (2017) stated that network could break through the fence of classrooms and schools for learning so that students could access distance education resources and courses without being restricted to distance as well as select online announcement, reading, or participating in discussion without being limited by time.

Guided Discovery Teaching

Hobday (2016) regarded guided discovery teaching as teachers interacting with students with problems and guiding students to discover important concepts with living problems, from old experiences to gradually getting into critical thinking and comprehensively evaluating learning activity, and connecting teaching with real life. Guided discovery learning therefore was to change traditional rules into lively and positive learning (Lam et al., 2016). Furthermore, Braithwaite et al. (2017) pointed out the characteristics of guided discovery teaching as students discovering problems, inquiring problems, and solving problems, like scientists. Such learning was to cultivate systematic inquiry ability and give scientific thinking opportunities at various stages, in which every thinking stage was the one-by-one development, to form the thinking learning cycle. Such teaching could train students' inductive and logic thinking and help establish good scientific attitudes. Accordingly, guided discovery teaching could guide students' active participation and induce some common points to help cultivate students' basic competency required for natural science (Nozari & Siamian, 2015). Guggenheim and Williams (2015) considered that teachers, in the teaching process, guided students to discuss problems step by step and students found out problems according to facts and collect and verify data to make reasonable explanations, and solve problem for new knowledge. The proposed four stages (Daly, Bulloch, Ma, & Aidulis, 2016) required the participation of students to provide scientific thinking opportunities. Hua et al. (2015) described the characteristics of guided inquiry teaching as students, like scientists, discovering problems, inquiring problems, solving problems, and seeking for solutions. Such learning was a systematic cultivation of inquiry ability to offer thinking opportunities at various stages; and, each thinking stage was the one-by-one development to form thinking learning cycle. Such teaching could train students' inductive and logic thinking and help establish good learning attitude.

Learning Achievement

Howard and Navarro (2016) referred learning achievement to learners, in specific learning environment, perceiving the intrinsic knowledge and achievement after learning through courses and materials. De Leeuw et al. (2016) described learning achievement as knowledge, comprehension, and skills acquired through special education experience with formal curricula and teaching design in schools, or an individual acquiring certain information and being familiar with certain skills through special teaching. Hua et al. (2015) pointed out learning achievement as what an individual could do academically, i.e. personal psychological capability performed on learning. Cadzow, Chambers, and Sandell (2015) mentioned that a lot of scholars regarded the close relationship between cognition in motivation & attitude and learning achievement, i.e. being able to predict learning outcome with motivation cognition and behavioral attitude. Such research assumed students' willingness and expected value in motivation factors, cognition in attitude factors, and perception of problems as the factors in students' learning strategies. The practice of such learning strategies would affect learning achievement. Leo (2017) regarded bad learning motivation, bad attitudes, students' education attainment and career ambition, peer relationship, self-identity, and appearance as major factors.

Referring to Cho, Shin, and Yu (2016), the following dimensions are proposed for learning achievement in this study.

(1) Socioeconomic status: Parents with higher education would be more willing to spend time for checking children's schoolwork, discuss learning experience, and instruct academic learning skills. Apparently, higher socioeconomic status shows strengths on children's learning.

(2) Peer relationship: It refers to individuals with similar ages exchanging experience and opinions, proposing questions, and questioning each other, through linguistic symbols and participation in activity, to construct personal thoughts and concepts.

(3) Learning skill: Learning skill (or learning strategy) is the method and route applied to learning. Learning skill allow students acquiring excellent performance at schools and benefiting lifelong. There are various types of learning skills applied to different occasions.

Learning Outcome

Learning outcome is generally the evaluation of learners after completing certain learning activity and the achievement of learning activity to the predicted effect (Lin & Chen, 2016). Ding et al. (2016) pointed out the consistent concepts of academic performance, learning outcome, or learning achievement, i.e. students' learning result on school subjects or persistent results through learning process. Surjono (2015) regarded the indicator to evaluate students' learning outcome as the major item to evaluate teaching quality. Learning outcome would be affected by curriculum design, teaching method, and learning behavior, and students' learning objectives were to monitor self-learning, reflect learned knowledge, and learn how to learn. In this case, learning outcome was the direct presentation of learning result. Chassine, Villain, Hamel, and Daien (2015) indicated that evaluation of learning outcome was the collect of data and information about student abilities satisfying course objectives; such evaluation was practiced in the course and was normally preceded by the assignation of work. McCann and Marek (2016) regarded learning outcome as the indicator to measure students' learning result as well as the major item to evaluate teaching quality; such performance evaluation could stimulate and induce students' learning, and the evaluation result allowed students and teachers understanding the learning and teaching results for explaining or improving teaching effect.

Referring to Guo et al. (2016), two dimensions are covered in learning outcome in this study.

(1) Learning effect－containing test performance, schedule completion time, and term scores.

(2) Learning gain－including learning satisfaction, achievement, and preference.

Research Hypothesis

Ding et al. (2016) regarded guided discovery teaching as giving instruction and guidance before or during students' inquiry, allowing students finding out answers in the inquiry process and encouraging students communicating the discovery; such teaching activity could help students comprehend the essence of knowledge and enhance students' learning achievement. Wong and Saw (2016) described the learning pattern of guided discovery teaching that instructors provided important basic data and proposed some questions to stimulate learners' interests and enhance learners exploring and thinking problem-solving methods. Zhou et al. (2017) explained such a teaching method allowing learners actively exploring knowledge as active explorers, rather than knowledge acceptors as in traditional teaching. In addition accumulating knowledge and learning problem-solving capability, such a method stressed on the thinking process in learning to effectively enhance students' learning achievement and allowed learners generating various concepts to enhance learning autonomy and generalization (Lam et al., 2016). The following hypothesis is therefore proposed in this study.

H1: Guided discovery teaching would affect learning achievement.

Guo et al. (2016) regarded guided teaching as the combination of leading organization and discovery learning for the synergistic effect that guided teaching was therefore generated. Xu, Wen, and Rissel (2015) explained that leading organization could cover new and old knowledge and provide the optimal cognitive anchorage at proper levels to establish subordinate and supervisor relationship between subsumers in new material concepts and learners' cognition structure. In other words, a cognitive bridge was built for meaningful learning to effectively enhance students' learning outcome. The characteristics of guided discovery teaching was to combine the spirit of discovery teaching with the consideration of real teaching schedule and train students problem-solving thinking habits and scientific attitudes. Teachers therefore had to design and arrange knowledge contents beneficial to students discovering "predicted learning" in real teaching situations and enhance students' learning outcome (Lin & Chen, 2016). The following hypothesis is then proposed in this study.

H2: Guided discovery teaching would influence learning outcome.

Cho et al. (2016) indicated that the point to practice guided discovery teaching with computer network technology was to provide interactive learning and induce intrinsic learning motivation. Learners proceeded independent or group operation activity in the interactive environment; the peer communication and feedback of operation experience allowed students' pleasant learning and learning achievement to enhance learning outcome. Learning without sense of achievement would have students lose self-confidence, perceive pressure of academic work, and lack interests to form vicious circle to influence the learning attitude and not to enhance learning outcome (You et al., 2014). Leo (2017) indicated that the higher learning achievement would enhance interests, and learning achievement was the motive to achieve the goal. In this case, learning achievement would affect learning outcome. Accordingly, the following hypotheses are proposed in this study.

H3: Learning achievement shows significantly positive effects on learning effect in learning outcome.

H4: Learning achievement reveals remarkably positive effects on learning gain in learning outcome.

RESEARCH METHOD

Measurement of Research Variable

Learning achievement

Referring to Cho et al. (2016), learning achievement is divided into (1) socioeconomic status, (2) peer relationship, and (3) learning skill.

Learning outcome

Referring to Guo et al. (2016), it contains (1) learning effect and (2) learning gain.

Research Object and Sampling Data

With quasi-experimental study, 252 students in Harbin Institute of Technology are selected as the research object. The experimental class (126 students) is proceeded guided discovery teaching with computer network technology, while the control class (126 students) remains traditional teaching method. The experimental teaching is preceded 16 weeks for 3 hours per week (total 48 hours). The retrieved data are analyzed with SPSS, and Regression Analysis and Analysis of Variance are applied to test various hypotheses.

Table 1. Analysis of Variance of the practice of computer network technology in guided discovery teaching on learning achievement

variable	F	P	Scheffe post-hoc
socioeconomic status	10.238	0.000*	guided>general
peer relationship	13.467	0.000*	guided>general
learning skill	12.551	0.002*	guided>general

* stands for $p<0.05$

Table 2. Analysis of Variance of the practice of computer network technology in guided discovery teaching on learning outcome

variable	F	P	Scheffe post-hoc
learning effect	18.716	0.000*	guided>general
learning gain	15.931	0.006*	guided>general

* stands for $p<0.05$

Table 3. Analysis of learning achievement to learning outcome

dependent variable →	learning outcome			
independent variable ↓	learning effect		learning gain	
learning achievement	Beta	t	Beta	t
socioeconomic status	0.153	1.764*	0.167	1.898*
peer relationship	0.178	2.045**	0.184	2.096**
learning skill	0.202	2.237**	0.211	2.344**
F	21.158		26.434	
significance	0.000***		0.000***	
R2	0.189		0.231	
Adjusted R2	0.164		0.192	

Note: * stands for $p<0.05$, ** for $p<0.01$

ANALYSIS RESULT

Effects of the Practice of Computer Network Technology in Guided Discovery Teaching on Learning Achievement and Learning Outcome

Analysis of Variance of the practice of computer network technology in guided discovery teaching on learning achievement

According to Analysis of Variance, the differences in the practice of computer network technology in guided discovery teaching on learning achievement is discussed in this study, i.e. analyses and explanations of socioeconomic status, peer relationship, and learning skill. From **Table 1**, the practice of computer network technology in guided discovery teaching shows significant effects on socioeconomic status (P=0.000*), peer relationship (P=0.000*), and learning skill (P=0.002*) that H1 is supported.

Analysis of Variance of the practice of computer network technology in guided discovery teaching on learning outcome

According to Analysis of Variance, the difference in the practice of computer network technology in guided discovery teaching on learning outcome is discussed in this study, i.e. the analyses and explanations of learning effect and learning gain. From **Table 2**, the practice of computer network technology in guided discovery teaching reveals remarkable effects on learning effect (P=0.000*) and learning gain (P=0.006*) that H2 is supported.

Correlation Analysis of Learning Achievement and Learning Outcome

Correlation Analysis of learning achievement and learning effect

To test H3, the analysis results, **Table 3**, reveal notably positive effects of socioeconomic status (t=1.764*), peer relationship (t=2.045**), and learning skill (t=2.237**) on learning effect that H3 is supported.

Correlation Analysis of learning achievement and learning gain

To test H4, the analysis results, **Table 3**, show significantly positive effects of socioeconomic status (t=1.898*), peer relationship (t=2.096**), and learning skill (t=2.344**) on learning gain that H4 is supported.

CONCLUSION

The research results show that guided discovery teaching could enhance students' learning achievement and learning outcome. When learners could not apply learned knowledge to solve new problems, effective prompts could activate the mind for learners grasping the potential structure of problems in the learning and approach proper information from teachers' guidance to extract relevant information from the memory. In the problems with similar structure, they could simulate the problem-solving and further explain logic thinking to achieve the learning effect. In this case, proper guidance could benefit discovery learning. By connecting learning materials and students' cognition structure in guided teaching, teachers provide a conceptual structure for students more stably combining and remaining detailed and differential materials, i.e. allowing students reorganizing information in the work memory to have the information present consistency for internal link as well as assist students in comparing the similarity and difference in the facts, concepts, and questions in the learning contents. The learning therefore is reorganized and integrated with existing knowledge. Such learning could help students apply the learned information to learning new materials. General teaching simply review the concept learned before. Although students notice new information, those with worse prior knowledge might transmit the learned information to the work memory, but could not combine it with present knowledge. Without internal link and external link, such information could merely be stored in long-term memory with the original state, but not being generalized to other similar learning situations. For this reason, students with general teaching appear worse learning achievement and learning outcome.

SUGGESTION

Aiming at above research results, the following suggestions are proposed in this study.

1. Teachers are suggested to analyze the contents of teaching units, list important concepts, and then inquire common teaching experiments or activity about the concepts, consider most students' existing knowledge and misconception on the concepts, rearrange the steps and sequence, and timely add problems which could induce students' thinking without frustration to enhance students' learning achievement. Meanwhile, students' inductive and logic thinking could be trained to help them establish good learning attitudes.
2. In consideration of student gap in the same class, teachers are suggested to apply cooperative learning to guided discovery teaching, group students heterogeneously, and have classmates with better degree assist those with bad degree in the learning. It would help the practice of guided discovery teaching.
3. When teachers intend to change the teaching to be construct-oriented, they need the evaluation tool which could authentically reflect students' knowledge construction ability. Similarly, teachers intending to change traditional pencil & paper tests and make the evaluation be authentic should present correspondent teaching behavior to make teaching livelier and pay attention to the spirits of enquiry and knowledge construction. It is suggested that teachers could start on the change of teaching and slowly look for proper evaluation materials in the teaching, gradually increase the proportion of performance evaluation in pencil & paper tests, and feedback the evaluation results to the teaching. In this case, it could improve teaching and evaluation effects.

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Effects of Using Artificial Intelligence Teaching System for Environmental Education on Environmental Knowledge and Attitude

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ABSTRACT

The emergence of computers resulted in the application revolution to instruction; till the emergence of the Internet, the strong communication ability became the major role and fully developed the integration of technology and network. The emergence of artificial intelligence teaching systems really fulfilled leaner-centered learning. Based on learner needs, the design changed the learning interaction in automatic teaching from the interaction with machines to the interaction with knowledge. With quasi-experimental study, total 186 college students, as the research object, are proceeded 16-week (3 hours per week for total 48 hours) environmental education with artificial intelligence teaching systems. The research results conclude significant correlations between 1.environmental education and environmental knowledge, 2.environmental knowledge and environmental attitude, and 3.environmental education and environmental attitude. According to the results, suggestions are proposed, expecting to reinforce the teaching ability of environmental education, cultivate college students' understanding of environment, enhance environmental protection knowledge, attitude, and action intention, as well as promote the skill to use environmental action strategies.

Keywords: artificial intelligence teaching system, environmental education, environmental knowledge, environmental attitude

INTRODUCTION

The emergence of computers resulted in the first application revolution of automatic instruction. The application presented the characteristic of computers being programmable. The emergence of the Internet, the automatic instruction with computers as the major teaching media, was the second application revolution of automatic instruction, in which computers became the supporting role, while the strong communication ability of the Internet became the major role. Education units in many countries realized the potential of network technology development, devoted to the application of network technology to instruction, and fully developed the integration of technology and network. The Internet, with the media characteristics of active knowledge exploration and huge users, immediately became a new battle for new and old automatic instruction technology. The emergence of artificial intelligence teaching systems really fulfilled the learner-centered learning. The learner need based design released the criticism of automatic instruction not stressing on human nature and changed the learning interaction in automatic instruction from the interaction with "machines" and "programs" to the interaction with "knowledge". With problem solving, artificial intelligence teaching systems did not simply provide "electronic books" with higher automation, but became the provider with high-quality one-to-one teaching environment.

When various countries largely developed the economy and accelerated the industry, the natural environment was seriously damaged to result in lots of environmental problems. Afterwards, people gradually concerned about environmental resources on the earth and realized that such resources should not be wasted. Some people were aware that environmental problems could be thoroughly solved merely by humans presenting keen awareness and

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Contribution of this paper to the literature

- Teachers, before engaging in related teaching, are suggested to acquire literature and network data related to environmental education, participate in relevant training activities, and interact with environmental protection related groups or people in order to broaden the professional knowledge and timely introduce to the courses to enrich the lessons.
- Environmental education as a part of formal education for college students receiving systematic environmental education, knowing environmental ecology, understanding the source of environmental pollution and the effect on life, and further cultivating the concept and behavior to protect the environment so as to benefit the success of environmental protection actions.
- To standardize the materials and describe the educational attributes, resource meanings, and general resource property of teaching materials.

brand-new understanding of the survival environment and cultivating the environmental action skills. Environmental education was the fundamental methods to promote environmental attitudes and environmental behaviors. By developing people's environmental knowledge and environmental value with environmental education to change the attitudes, people would naturally emphasize environmental issues and take beneficial behaviors for the environment, i.e. being responsible for the environment, particularly the environmental knowledge of the next generation and the habit to protect the environment. This study therefore precedes environmental education with artificial intelligence teaching systems to understand the effect on knowledge and attitude. It is expected to reinforce the teaching ability of environmental education, cultivate college students' understanding of environment, enhance the environmental knowledge, attitudes, and action intention, as well as promote the skills to use environmental action strategies.

LITERATURE REVIEW

Artificial Intelligence Teaching System

Lai (2016) simply defined artificial intelligence as a computer system with human knowledge and behaviors and solving problems, memorizing knowledge, and understanding human natural language through learning and reasoning. Ng (2016) described the generation of artificial intelligence (AI) as decomposing the processes of human stimuli and responses induced by problems and affairs as well as the reasoning, problem-solving, learning, judging, and thinking of decisions into basic steps and modularizing or formulating problem-solving processes through programming so that a computer could be designed with structural methods or cope with more complicated problems. Hwang, Kongcharoen, and Ghinea (2014) regarded an artificial intelligence teaching system as a computer-based teaching system which could simulate human teachers, detect learners' learning conditions, and determine what to teach, when to teach, and how to teach with AI technology. Ricoy and Feliz (2016) indicated that an artificial intelligence teaching system aimed to provide each college student with possible teaching assistance as one-to-one teaching from a senior teacher. To achieve such an objective, four independent elements of college student model, teaching module, domain knowledge, and interface module were designed. "Curriculum sequencing", "intelligent analysis of student's solutions" and "interactive problem-solving support" were adopted as the core technology. An emerging technology, "example-based problem-solving support", was added after 1990 (Lai & Chen, 2014).

Environmental Education

Environmental education is the education process, aiming at the correlation between humans and the natural environment & artificial environment, including population problems, pollution problems, energy allocation and conservation problems, natural conservation problems, technology development, traffic infrastructure, as well as urban and rural plans, to have the citizens understand the relationship with the environment through education (Sáez-López, Román-González, & Vázquez-Cano, 2016). Cela, Sicilia, and Sánchez (2015) mentioned that environmental education was the process to recognize value and clarify concepts so as to cultivate necessary skills and attitudes for understanding and appreciating the interaction between humans, culture, creatures and physical environment. Environmental education should also be expanded to decision-making related to environmental quality and self-behavior regulations. Nikou and Economides (2017) regarded environmental education as the education process, in which individuals and the society knew the environment and interacted with the environment compositions of creatures, physical and social culture, acquired knowledge, skills, and value, and could individually or collectively solve environmental problems. de-Marcos et al. (2016) stated that environmental education was the education process aiming to improve the environment and the education process to clarify concepts and form value as well as necessary knowledge, skills, and attitudes for people understanding and experiencing the interactive relationship between humans and culture, creatures, physical. Environmental education also taught people to make decisions, when facing issues related to environment quality, and develop the principle for self-behaviors. Sheorey (2014) indicated that environmental education aimed to cultivate people in the world noticing the environment and the problem solving, concerning about the environment, presenting problem-solving capability on environmental problems, and being able to prevent from possible problems in the future. For this reason, every one or group in the world should be taught necessary knowledge, skills, attitudes, willingness, and practice abilities so as to acquire proper coping strategies to deal with and prevent from environmental problems.

The dimensions proposed by Dong, Zhang, Dai, and Guan (2014) are used for deeply discuss environmental education.

(1) Knowledge concept: Referring to the environment and the surrounding natural ecology, geomorphologic characteristics, environmental ecological cycle, pollution concepts, environment maintenance, and limit environmental resources.

(2) Affection concept: Referring to concerns about environment, appreciation of nature beauty, correct environmental ethics and value, and integration of environmental culture and art.

(3) Technical concept: Referring to the prevention of environmental pollution, water purification, development and management of environmental resources, conservation of environmental resources, and environmental protection behaviors.

Environmental Knowledge

Lee (2014) regarded environmental knowledge as individual understanding of the environment. Jeno, Grytnes, and Vandvik (2017) considered that environmental knowledge was an interdisciplinary subject, whose knowledge was induced by natural and social science and anthropology; sometimes, it involved in value and division of power and covered broadly, including food, clothing, housing, and transportation for human beings. Knowledge related to life and environment therefore could be regarded as environmental knowledge (Chou, Lunsford, & Thomson, 2015; Hosseinnezhad, 2017). Environmental knowledge was generally referred to individual understanding of environmental affairs (Sarkar & Petrova, 2013), with broad coverage. Park and Lee (2014) indicated that environmental knowledge contained 1. knowledge of environmental issues, 2. knowledge related to environmental action strategies, and knowledge of action skills.

Referring to Lai and Hwang (2015), the following three dimensions are applied to environmental knowledge.

(1) Nature knowledge: Including issues of biology and ecology, e.g. compositions and functions of ecological systems, flow of materials and energy in ecological systems, ethnic groups and clusters, and effect of humans on ecological systems.

(2) Problem knowledge: Containing resources in natural environment and environmental problems caused by overuse of natural resources.

(3) Action strategy: Types of environmental actions, solving problems with proper actions, and skills to use environmental actions (Sllame & Jafaray, 2013).

Environmental Attitude

Joo-Nagata, Abad, Giner, and García-Peñalvo (2017) referred “environmental attitude” to the compositions of special situations in the environment, the entire environment, or the belief of people or objects directly related environment. Such compositions contained the overall evaluation of for or against, like or dislike. PlanasLladó et al. (2014) regarded “environmental attitude” as college students’ value of the entire environment, the opinions about humans’ responsibilities and roles in the environment, individual perception of affairs related to environment with the emotional tendency of for or against, like or dislike, e.g. self-perception of the responsibility for the environment and the concerns about environment problems. Shadiev, Hwang, Huang, and Liu (2015) pointed out environmental attitude as the compositions of special situations in the environment, the entire environment, or people, affairs, and objects directly related to the environment. Such compositions included the overall evaluation of for or against and like or dislike (Darvin & Norton, 2014). Accordingly, environmental attitude referred to individual opinions about the value of the entire environment and human responsibility and role in the environment (Vanderhoven et al., 2015).

Referring to Huang et al. (2014), the following dimensions are used for environmental attitude in this study.

(1) Environmental sensitivity: Referring to the seriousness of environmental problems and individual opinions about the relevance. The cultivation requires long-term natural experience or model guidance in life.

(2) Environmental belief: Referring to individual ideas about the mutual relationship between humans and natural environment. It is divided into mainstream society model and new environment model.
(3) Environmental value: Referring to individual perceived value of environment and the relevant problems.
(4) Environmental ethics: Humans' belief in environmental ethics expands from individual to family, region, nation, human beings, creatures, inanimate objects, and the universe, i.e. expanding from "human-centered ethics" to "life-centered ethics" and to "ecology-centered ethics".

Research Hypothesis

In the study on the effect of environmental teaching on college students' environmental awareness, attitudes, and behaviors, Xu, Huang, and Tsai (2014) concluded top five sources of environmental knowledge as television, newspaper, parents, teachers, and schools. Cela et al. (2015) indicated that senior college students mainly acquired ecological conservation knowledge from mass media or texts, followed by computer networks, teachers' lectures, and school courses. García-Saiz, Palazuelos, and Zorrilla (2014) mentioned that television and teachers' lectures were the major sources of water resource conservation knowledge for college students. Dong et al. (2014) proceeded environmental education with the environmental protection area, Sihcao Wildlife Reserve, and revealed that field trips, mass media, and lessons were the major knowledge sources for college students. Accordingly, environmental education activities arranged by teachers or schools could largely enhance college students' environmental knowledge (Sarkar & Petrova, 2013). According to above literatures, the following research hypothesis is inferred in this study.

H1: Environmental education shows significant correlations with environmental knowledge.

Lai and Hwang (2015) pointed out the remarkable correlation between college students' environmental knowledge and attitudes toward oceans. Molano and Polo (2015) found out the notable correlation between environmental knowledge and environmental attitude of learners in public vocational training institution. Park and Lee (2014) discovered that college students with higher environmental knowledge presented more positive attitudes toward the environment. Yilmaz (2016) found out the significantly positive correlation between high school teachers' environmental sensitivity and environmental knowledge. Other researchers (Sáez-López et al., 2016) also discovered the positive correlation between environmental knowledge and environmental attitude of college students after receiving 4-8 week environmental courses or programs. Apparently, education behaviors could positively promote environmental knowledge and environmental attitude. Regarding the correlation between cognition and affection, Nikou and Economides (2017) stated that college instructors' environmental knowledge, cognition of environmental problems in Taiwan, environmental awareness, and cosmic belief appeared positive correlations with social value. Based on above studies, the following research hypothesis is inferred in this study.

H2: Environmental knowledge reveals remarkable correlations with environmental attitude.

Huang et al. (2014) pointed out the positive effect of designed environmental education on college students' "environmental attitude". Xu and He (2014) designed the course for river environmental education to effectively enhance the river conservation attitudes of college students in the experimental group, and the posttest mean remarkably outperformed the pretest mean. Shadiev et al. (2015) pointed out the better posttest performance on environmental attitude of college students in the experimental group than the pretest, i.e. environmental issue integrated environmental education being able to promote college students' environmental attitudes. Joo-Nagata et al. (2017) regarded the final goal of environmental education as to cultivate the citizens with environmental literacy so as to cultivate the basic knowledge of environment, promote problem-solving skills, and enhance environmental action participation and attitudes. Lee (2014) considered that the goal of environmental education should focus on college students being able to experience the environment and teach basic environmental knowledge between humans and environment, aiming to cultivate college students' attitudes toward environmental protection, reinforce environmental attitude education, and put it into practice to maintain environmental quality in daily life. According to above literatures, the following research hypothesis is proposed in this study.

H3: Environmental education presents notable correlations with environmental attitude.

SAMPLE AND MEASURING INDICATOR

Research Sample and Object

With quasi-experimental research, total 186 college students, as the research object, are proceeded 16-week (3 hours per week for total 48 hours) environmental education with artificial intelligence teaching systems. The research data are analyzed with computer statistics software and various hypotheses are tested.

Reliability and Validity Test

Validity refers to the measuring tool being able to really measure the problems which a researcher really intends to measure. Generally speaking, validity is divided into content validity, criterion-related validity, and construct validity. The items in the questionnaire in this study are referred to domestic and international researchers, and, before the distribution of formal questionnaire, the pretest is preceded after discussing to the tutor that it presents certain content validity. Environmental education, environmental knowledge, and environmental attitude are tested the overall structural causality with linear structural relation model, and the data entry is based on the correlation coefficient matrix of above observation variables. The linear structural relation model analysis results reveal the overall model fit reaching the rational range that it shows favorable convergent validity and predictive validity. Item-to-total correlation coefficients are used for testing the construct validity of the questionnaire content, i.e. reliability analysis. The calculated item-to-total correlation coefficients are utilized for judging the questionnaire content. The item-to-total correlation coefficients of the dimensions in this study are higher than 0.5, revealing certain degree of construct validity.

Reliability and validity analyses are further preceded. The higher Cronbach's α shows the better reliability. The Cronbach's α higher than 0.7 presents high reliability, while the Cronbach's α lower than 0.35 should be eliminated, and the value in 0.7~0.98 is regarded as high reliability. Moreover, item-to-total correlation coefficients should be higher than 0.4, and those not conforming to the standard should be deleted. The formal questionnaire in this study is developed according to above standards, and the measured Cronbach's α appears in 0.70~0.80, obviously conforming to the reliability range.

Furthermore, discriminant validity would test the discrimination among dimensions with the square root of average variance extracted of individual dimension and the correlation coefficients of other dimensions. When the former is larger, the model shows discriminant validity. Accordingly, the square root of average variance extracted of "environmental education", "environmental knowledge", and "environmental attitude" are calculated, which are further compared with the correlation coefficients of dimensions. Apparently, the dimensions in this research model present discriminant validity.

ANALYSIS OF EMPIRICAL RESULT

LISREL Model Assessment Indicator

LISREL (linear structural relation) model combines factor analysis and path analysis in traditional statistics with simultaneous equations in econometrics that it could calculate multiple factors and multiple causal paths. The model fit could be evaluated from preliminary fit criteria, overall model fit, and fit of internal structure of model.

The research data are organized in **Table 1**. Preliminary fit criteria, fit of internal structure of model, and overall model fit are explained as below.

From **Table 1**, the dimensions of environmental education (knowledge concept, affection concept, technical concept) could significantly explain environmental education ($t>1.96$, $p<0.05$), the dimensions of environmental knowledge (nature knowledge, problem knowledge, action strategy) could remarkably explain environmental knowledge ($t>1.96$, $p<0.05$), and the dimensions of environmental attitude (environmental sensitivity, environmental belief, environmental value, environmental ethics) could notably explain environmental attitude ($t>1.96$, $p<0.05$). Apparently, the overall model in this study shows favorable preliminary fit criteria.

In terms of fit of internal structure of model, environmental education presents positive and significant correlations with environmental knowledge (0.866), environmental knowledge shows positive and remarkable correlations with environmental attitude (0.883), and environmental education reveals positive and notable correlations with environmental attitude (0.871) that H1, H2, and H3 are supported.

In regard to overall model fit, the standards $\chi2/Df=1.462$, smaller than the standard 3, RMR=0.007 show the appropriateness of $\chi2/DF$ and RMR. Besides, chi-square is sensitive to sample size that it is not suitable for directly judging the fit. The overall model fit standards GFI=0.934 and AGFI=0.904 are higher than the standard 0.9 (the closer GFI and AGFI to 1 revealing the better model fit) that the model shows better fit indices.

Table 1. Analysis result of overall linear structural relation model

evaluation item	parameter/evaluation standard		result	t
preliminary fit criteria	environmental education	knowledge concept	0.683	9.88**
		affection concept	0.672	9.16**
		technical concept	0.694	10.79**
	environmental knowledge	nature knowledge	0.637	7.46**
		problem knowledge	0.642	7.91**
		action strategy	0.651	8.22**
	environmental attitude	environmental sensitivity	0.702	8.92**
		environmental belief	0.697	11.02**
		environmental value	0.687	10.14**
		environmental ethics	0.711	13.31
fit of internal structure of model	environmental education→environmental knowledge		0.866	22.45**
	environmental knowledge→environmental attitude		0.883	27.39**
	environmental education→environmental attitude		0.871	24.61**
overall model fit	Squared chi-square value/degree of freedom		1.462	
	fit index		0.934	
	adjusted fit index		0.904	
	residual root mean square		0.007	
	Standardized fit index		0.913	

Table 2. Test of hypothesis

research hypothesis	correlation	empirical result	P	result
H1	+	0.866	0.00	supported
H2	+	0.883	0.00	supported
H3	+	0.871	0.00	supported

CONCLUSION

The research results reveal positive and remarkable effects of environmental education on environmental knowledge and environmental attitude. The results show that environmental education with artificial intelligence teaching systems could obviously enhance college students' environmental knowledge and concepts, change the attitudes and concerns about environment, as well as promote the belief and perception of environment friendliness; besides, college students' insight and sensitivity to environmental pollution are obviously reinforced. From the aspect of artificial intelligence teaching systems, the intelligent behavior of a system is the information of teaching module, according to college students, matching with knowledge structure in the domain knowledge to determine proper teaching strategies as ruled and present the results with the interface for communicating the knowledge with the users. For the users, the final presentation of knowledge is extremely important. From the process of college students' environmental education with the artificial intelligence teaching system, college students feel the learning fun in the environmental education with artificial intelligence teaching systems and enhance the knowledge. In the learning situation of environmental education with artificial intelligence teaching systems, college students could positively participate in the discussion of environmental issues and concern about them, without being restricted to the dull environmental knowledge on textbooks. More importantly, environmental education with artificial intelligence teaching systems could have the courses be funnier and extend college students' creation of imagination so that they would like to be a part of it.

RECOMMENDATIONS

According to the research results and findings, practical suggestions are further proposed in this study.

1. Under multiple environmental issues and diverse environmental protection, existing knowledge could no long cope with the changeable environmental problems. Teachers, before engaging in related teaching, are suggested to acquire literature and network data related to environmental education, participate in relevant training activities, and interact with environmental protection related groups or people in order to broaden the professional knowledge and timely introduce to the courses to enrich the lessons.
2. It is suggested to regard environmental education as a part of formal education for college students receiving systematic environmental education, knowing environmental ecology, understanding the source of environmental pollution and the effect on life, and further cultivating the concept and behavior to protect

the environment so as to benefit the success of environmental protection actions. Moreover, teachers should flexibly apply distinct teaching strategies with artificial intelligence teaching systems and stress on college students' individual differences so that college students could easily understand the environmental education content and present higher learning interests to make environmental education be more effective.

3. To have artificial intelligence teaching systems present the maximal flexibility to reconstruct material knowledge, according to the teaching module, the knowledge structure in domain knowledge presents the critical status. It is therefore suggested to standardize the materials and describe the educational attributes, resource meanings, and general resource property of teaching materials. In this case, any materials conforming to the same standards could be easily retrieved the education related information with the artificial intelligence teaching system, including learning concepts and the relationship with other concepts. It would not only solve the problem of speed for developing artificial intelligence teaching systems, but would also achieve the objectives of material sharing and repeated use.

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A Study on the Effect of Continuing Education with Digital Technology on Professional Growth and Job Satisfaction of Librarians

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ABSTRACT

Digital technology and Internet have been combined with modern people's life, and the combination of bit technology with network communication systems largely change people's lifestyles. Along with the popularity of education, the application of digital technology also enhances the basic changes of learning methods and learning contents. To provide quality service, professional librarians are necessary for a library. Accordingly, librarians are the core management element of a library. In the changeable technology era, librarians need constant learning for self-growth through continuing education in order to cope with the changeable environment. Taking librarians of Shanghai University of Medicine & Health Sciences as the research object, the librarians are proceeded continuing education with digital technology, and the questionnaire is distributed and collected on-site after the continuing education. The research results show that 1.continuing education would significantly and positively affect professional growth, 2.professional growth would remarkably and positively affect job satisfaction, and 3.continuing education would notably and positively affect job satisfaction. With such results, suggestions are proposed, expecting to apply the professional curricula of continuing education with digital technology for the continuous growth of librarians in the changeable era, satisfying the enhancement of core competencies to cope with reader needs under the time and technology changes, and further promoting domestic librarians' professional competence and the development of library business.

Keywords: digital technology, library, continuing education, professional growth, job satisfaction

INTRODUCTION

Digital technology and Internet have been combined with the life of modern people. Carrying mobile phones out, using 3C products of PDA, notebook computers, MP3, and iPod, turning on computers for online chatting, online games, checking e-mails, looking up data, and even online shopping are an important part of modern people's life. Filing tax return, paying bills, and holding video conference through networks have also become the routines of office workers. Regardless the distance of customers, transactions could be completed through e-commerce systems to achieve the objective of rapid, convenient, and saving resources. Networks have replaced a lot of troubled artificial operations and break through the restriction to distance to achieve the borderless information transmission. The combination of bit technology with network communication systems largely changes people's lifestyles. When the society develops to certain degree, people would enhance the concerns about education and expectation. The popularity of education and the application of digital technology also facilitate the basic changes of learning methods and learning contents to focus on education quality.

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Contribution of this paper to the literature

- A school should provide subsidies and resources, as regulated, for librarians, according to individual needs, selecting proper lessons for continuing education and contacting the application of digital technology to achieve the professional growth and reserve talents.
- The network learning communication platform could be established with digital technology for librarians recording the learning opinions and experience exchange so as to enhance librarians' professional growth.
- The participation in continuing education with digital technology is listed in the evaluation for promotion and position adjustment, and librarians with positive learning should be rewarded and praised.

A library is composed of buildings, collections, readers, and librarians (Racelis, 2018). To provide quality service, a library needs professional librarians who are therefore the core management element of a library. In the changeable technology era, it is necessary for librarians' constant learning and self-growth through continuing education to cope with such a changeable environment. From a traditional library to a digital library and a mobile library, a library continuously changes and makes progress with the evolution of time with technology progress, changes of users' usage behaviors, and transformation of library functions to prove "a library as an organism of growth". For this reason, major learning channels of degree studies, professional credit courses, short-term studies, digital learning, seminars, business related conference, and book clubs could promote librarians' core competencies. Applying professional curricula of such continuing education with digital technology allows librarians continuously growing in the changeable era, satisfies librarians' enhancement of core competencies, and copes with reader needs under the time and technology changes to further promote domestic librarians' professional competence and the development of library business.

LITERATURE REVIEW

Digital Technology

Maeng and Lee (2015) indicated that bit technology contained emerging science technologies of Artificial Intelligence (AI), Data Analytics, Cloud Computing, Virtual Reality (VR), Augmented Reality (AR), and Block Chain. Atenas and Havemann (2014) mentioned that the application of high technology became more important with the time progress; the match of tools, materials, and technologies changed impossible into possible. As the idea of "converting atoms into bits" mentioned in *Being Digital*, it broke traditional thinking of physical production and simulated real space planning with Virtual Reality. Woo (2014) combined bitmap with new product development to prepare the expansion of marketing channels before the release of products. Besides, bit media, with the feature of audio and video, showed a positive impact on product presentation. They were the best proofs of the integration of digital technology. Ibáñez, Serio, Villarán, and Kloos (2014) indicated that technology development provided lots of new materials and new creation topics for education creation, e.g. replacing a brush with a mouse or a graphics table, replacing canvas with screen server, and replacing substantial space with virtual space. The reproducible, editable, and rich image processing largely resulted in visual impact. Digital technology did not simply introduce new tools or media, but also changed the cognition of affairs (Manek, Shenoy, Mohan, & Venugopal, 2014). With continuous changes of user experience in new-style interactive products, new modes of operation and usage habits were generated. Accordingly, software businesses, with the mature development of hardware technology, provided diverse application software for users perceiving the convenience of such new-style smart mobile devices by changing the past electronic product operation experience and methods (Rambli, Matcha, & Sulaiman, 2013).

Continuing Education

Sanjay (2016) pointed out continuing education, in adult education dictionary, as educational activities in which adults continuously participated after leaving formal education and prolonged to the life. It provided adults with education or educational activities of professional competence after leaving formal schools, i.e. learning activities extending in individual life (Di Serio, Ibáñez, & Kloos, 2013). Agarwal and Mittal (2014) referred continuing education as learning activities after stopping full-time compulsory education which could be full-time or part-time, occupational or non-occupational learning activities. Izenman (2013) regarded continuing education as primary, intermediate, and higher education opportunities offered by public and private institutions for people at various age levels, including courses of academic, occupational, leisure, and individual development. Bourgonjon et al. (2013) regarded continuing education as planned and systematic learning activities, aiming to have librarians keep new concepts, advance knowledge and technology, update basic education, and prepare for changing work. In this case, the content was not restricted to the positions, but covered the influence on service. MichelaMortara et al. (2014) considered that continuing professional education presented the property of career education, was practice oriented, and focused on in-service professional staff; the contents were professional knowledge and skills of professional industries; and, the method contained formal and informal teaching styles, but mainly informal.

Referring to Chen, Tan, and Lo (2016), the following dimensions are proposed for librarians' continuing education in this study.

(1) Job skills: To make changes, a library has to practice trainings to make up inadequate skills, prevent from getting out of date, and have the business operating conform to the trend.

(2) Professional knowledge: With continuing education, librarians could constantly absorb new knowledge, understand the trend of library business, and complement "professional new knowledge" and "job skills" to promote the library operating efficiency and efficacy.

(3) Self-development: The practice of "enriching work" and "expanding work" could be achieved through continuing education so that librarians could satisfy the need for self-fulfillment and tightly combine librarians career planning with library operating to fully develop the goal management.

Professional Growth

Ghorbandordinejad and Ahmadabad (2016) mentioned that being professional should constantly accept studies and tests to maintain the professional competence, and "growth" presented the meanings of advance and enhancement. In this case, "professional growth" referred to constantly receiving studies and tests in the execution of professional roles to seek for the continuous progress and growth of professional competence. Molaee and Dortaj (2015) referred professional growth as the constant development to cope with external environment and stress so as to improve professional knowledge and skills. It was not a static concept, but a dynamic process. Alickovic and Subasi (2016) designed a series of processes and activities to enhance personnel's professional knowledge, skills, and attitudes that presented three characteristics of the process with goals, a continuous process, and a systematic process. Jin, Zhao, Chow, and Pecht (2014) indicated that professional growth was not simply the acquisition of facts and knowledge, but a dynamic learning process to understand all affairs and enhance the familiarity to work environment. Cai, Wang, and Chiang (2014) referred to the efforts and willingness for the progress and development of constantly pursuing individual professional competence, skills, and attitudes, covering formal and informal activities for individual positive growth.

Referring to Lee and Hao (2015), the dimensions of administrative competence, professional competence, and professional ethics for librarians' professional growth are utilized in this study.

(1) Administrative competence: The role of a librarian was not simply the information worker. Along with the change of professional roles, a librarian had to cultivate the administrative competence of other relevant affairs, such as policy marketing, public relationship, customer relationship management, and information technology.

(2) Professional competence: An excellent librarian had to present professional competence to complete various services.

(3) Professional ethics: Professional ethics referred to certain professional personnel (e.g. physicians, solicitors, teachers, judges, engineers, accountants, architects) following the moral regulations and responsibilities.

Job Satisfaction

Hsu (2014) regarded job satisfaction as the attitude or emotional reaction to work, work environment, or the combination of the two. Employees with high job satisfaction would normally present better results, e.g. being actively to match organizational goals, being interested in the job and working harder. An organization therefore should create the situation beneficial to employees' job satisfaction to induce employees achieving goals and performance (Chiu, 2014). Qi, Tian, and Shi (2013) referred job satisfaction to individual awareness of subjective state, originated from positive and pleasant affective reaction at work. Aldhafri, Alkharusi, and Al Ismaili (2015) considered job satisfaction as workers giving positive or negative attitudes or feelings about work or specific layers at work which was the intrinsic psychological state. Young and Wang (2014) indicated that it was the overall subjective value judgment of a worker to the work, working process, or results and the reaction of feeling, attitude, or affection; the satisfaction relied on the gap between the actually acquired value and the expected value; the gap was inversely proportional to satisfaction. Khalid, Khalil, and Nasreen (2014) regarded it as workers' attitude or affective reaction to current positions and the overall feeling and subjective value judgment in the working process that the satisfaction relied on the gap between the actually acquired value and the expected value in specific work environment; and, the smaller gap showed the higher satisfaction. Wang and Han (2015) divided job satisfaction into internal, external, and overall. Internal satisfaction referred to a worker's satisfaction with the value, responsibility, sense of achievement, social status, occupational status, and opportunity to apply abilities induced at work. External satisfaction referred to the satisfaction with the salary and promotion acquired at work, the interaction with the supervisors, subordinates, and colleagues, company policies, as well as practice methods. Overall satisfaction indicated the entire internal and external satisfaction. Referring to Tang (2016), job satisfaction is the positive affection and opinions of workers to the entire work that the single dimension is used for measuring job satisfaction in this study.

Hypothesis Derivation

Maeng and Lee (2015) mentioned that the citizens were positively promoted and encouraged to participate in lifelong learning; especially, staff in public institutions was holding a lifelong learning passport, and there was a complete website management mechanism for public servants' lifelong learning. Libraries also utilized continuing education for enhance the emphasis on professional growth in past years. Sanjay (2016) found out the highly positive correlation between continuing education and professional growth, revealing that the more positive participation in continuing education would assist more in the professional growth. In this case, librarians with more opportunities to receive continuing education would show better professional growth. Seri, Ibáñez, and Kloos (2013) pointed out three major factors in college librarians' continuing education, including the consensus between supervisors and librarians, dissatisfaction with the need for continuing education, and the acquisition of continuing education to enhance professional growth. Chen et al. (2016) indicated that librarians could enhance professional growth with continuing education, and reading books and journals, participating in seminars, and correspondence or air instruction were the common methods. The following hypothesis is therefore proposed in this study.

H1: Continuing education would significantly and positively affect professional growth.

Molaee and Dortaj (2015) studied job satisfaction and professional growth and revealed that participation in professional growth activities, e.g. credit courses, degree courses, or non-credit courses, could enhance the promotion opportunity and remuneration, remarkably enhance satisfaction with knowledge sharing and peer acceptance, and make progress on the control of ability and work environment. In other words, professional growth could enhance job satisfaction. Subasi, Alickovic, and Kevric (2017) pointed out the notable correlation between professional growth opportunities and job satisfaction. People without professional growth opportunities would more easily quit the job that providing professional growth opportunities would enhance job satisfaction and reduce job burnout and turnover rate. Alickovic and Subasi (2016) considered that professional growth could enhance the responsibility and confidence in job as well as stimulate thinking to further engage in study, change, and update knowledge, increase sense of job achievement, and acquire promotion for the status of nursing leaders. Such incentives to work could enhance job satisfaction. Accordingly, the following hypothesis is derived in this study.

H2: Professional growth would remarkably and positively affect job satisfaction.

Lee and Hao (2015) indicated that training contents, teacher quality, and training effectiveness in continuing education showed significantly positive effects on satisfaction. Wang and Han (2015) pointed out the remarkably positive effects of training plan, environment equipment, and training effectiveness in continuing education on satisfaction with value commitment. Uysal and Gunal (2014) stated the notably positive effects of teacher quality, environment equipment, and training effectiveness in continuing education on satisfaction, and continuing education planning and training effectiveness presented significantly positive effects on retention commitment. Tang (2016) indicated that employees with better reaction to continuing education would reflect stronger job satisfaction to further present higher organizational commitment. For this reason, enhancing employees' positive reaction after continuing education and further reinforce the learning effectiveness and professional growth were the keys in promoting the job satisfaction. The following hypothesis is therefore derived in this study.

H3: Continuing education would notably and positively affect job satisfaction.

RESEARCH METHOD DESIGN

Research Object

Librarians of Shanghai University of Medicine & Health Sciences, as the research samples, are proceeded continuing education with digital technology. The questionnaire is distributed and collected on-site after the continuing education. Shanghai University of Medicine & Health Sciences, the direct university of Shanghai Municipal Education Commission, was established in May 2015. The library was established at the same time. The head library is located in the south building of Pudong campus, and there are branches in the north building of Pudong campus and Xuhui campus. The library of Shanghai University of Medicine & Health Sciences insists on the goal of "passing down civilization and wisdom to educate people", focuses on student growth, and constantly expands and innovates with teacher service as the key point. According to "the combination of medical treatment

Table 1. Analysis of continuing education to professional growth

dependent variable →	professional growth					
independent variable ↓	administrative competence		professional competence		professional ethics	
continuing education	Beta	t	Beta	t	Beta	t
job skills	0.172	1.816*	0.163	1.722*	0.177	1.849*
professional knowledge	0.183	1.944*	0.191	2.086**	0.158	1.683*
self-development	0.169	1.789*	0.188	1.975*	0.198	2.106**
F	22.431		28.615		33.462	
significance	0.000***		0.000***		0.000***	
R2	0.233		0.251		0.296	
adjusted R2	0.202		0.227		0.268	

Note: * stands for $p<0.05$, ** for $p<0.01$, *** for $p<0.001$.
Data source: Self-organized in this study

and health, medical treatment and engineer, medical treatment and insurance", the school positively develop, expand, and integrate various resources to establish a characteristic library for the guarantee of teaching and scientific research as well as the fulfillment of an applied, characteristic, and international medical college.

Analysis Method

Regression analysis is applied to understand the relationship among continuing education, professional growth, and job satisfaction.

ANALYSIS RESULT

Reliability and Validity Analysis

With factor analysis, three factors of "job skills" (eigenvalue=3.162, α=0.83), "professional knowledge" (eigenvalue=2.738, α=0.81), and "self-development" (eigenvalue=2.334, α=0.87) are extracted for continuing education. The common cumulative variance explained achieves 78.671%.

Professional growth, with factor analysis, are extracted three factors of "administrative competence" (eigenvalue=2.773, α=0.82), "professional competence" (eigenvalue=2.125, α=0.84), and "professional ethics" (eigenvalue=1.834, α=0.80). The common cumulative variance explained reaches 80.266%.

With factor analysis, job satisfaction shows the eigenvalue=4.127, α=0.89, and the common cumulative variance explained achieves 83.221%.

Correlation Analysis of Continuing Education and Professional Growth

To test H1, **Table 1** reveals that job skills (t=1.816*), professional knowledge (t=1.944*), and self-development (t=1.789*) present significant effects on administrative competence; job skills (t=1.722*), professional knowledge (t=2.086**), and self-development (t=1.975*) show remarkable effects on professional competence; and, job skills (t=1.849*), professional knowledge (t=1.683*), and self-development (t=2.106**) appear notable effects on professional ethics. H1 is therefore supported.

Correlation Analysis of Professional Growth and Job Satisfaction

To test H2, **Table 2** shows remarkable effects of administrative competence (t=2.231**), professional competence (t=2.134**), and professional competence (t=2.327**) on job satisfaction that H2 is supported.

Table 2. Analysis of continuing education to job satisfaction

dependent variable → independent variable ↓	job satisfaction	
professional growth	**Beta**	**t**
administrative competence	0.212	2.231**
professional competence	0.206	2.134**
professional ethics	0.227	2.327**
F	25.421	
significance	0.000***	
R2	0.188	
adjusted R2	0.163	

Note: * stands for p<0.05, ** for p<0.01, *** for p<0.001.
Data source: Self-organized in this study

Table 3. Analysis of professional growth to job satisfaction

dependent variable → independent variable ↓	job satisfaction	
continuing education	**Beta**	**t**
job skills	0.219	2.289**
professional knowledge	0.207	2.166**
self-development	0.236	2.414**
F	26.751	
significance	0.000***	
R2	0.269	
adjusted R2	0.245	

Note: * stands for p<0.05, ** for p<0.01, *** for p<0.001.
Data source: Self-organized in this study

Correlation Analysis of Continuing Education and Job Satisfaction

To test H3, Table 3 presents notable effects of job skills (t=2.289**), professional knowledge (t=2.166**), and self-development (t=2.414**) on job satisfaction that H3 is supported.

CONCLUSION

The research results show notable effects of continuing education on professional growth. Since librarians' professional growth is a continuous process, there is not the knowledge of an industry being able to be permanently used, without improving the technology. To provide quality service, a library needs professional librarians. Along with the constant changes of user experience in new-style interactive products, the professional growth of librarians, who should have advanced knowledge or technology, is more important. For this reason, a school should encourage the librarians participating in continuing education with the application of digital technology to enhance the academic attainment. The professional curricula of such digital technology applied continuing education allow librarians keeping up with the time for continuous growth to satisfy reader needs under the time and technology changes. Furthermore, education administration authorities and colleges & universities, in the lifelong learning era, should commonly plan training courses of library information and administration management with digital technology, make healthy mechanisms for teaching at different classes and training at various levels, encourage librarians' diverse participation, and timely give encouragement and support. In this case, librarians would be enhanced the intention to participate in learning and promote the professional growth.

RECOMMENDATIONS

Aiming at above research results, the following suggestions are proposed in this study.

1. A library is suggested to actively provide various digital technology applied continuing education related information, announce relevant regulations, and encourage librarians participating in the study. A school should provide subsidies and resources, as regulated, for librarians, according to individual needs, selecting proper lessons for continuing education and contacting the application of digital technology to achieve the professional growth and reserve talents.

2. A library is an organism for knowledge growth. The knowledge and experience of librarians are the intelligent property of a library that they should be emphasized and shared with each other. Librarians, after receiving continuing education with digital technology, are willing to share with the colleagues. The training reports, handout sharing, or continuing education in the library are the sharing of knowledge learning in a library. Moreover, the network learning communication platform could be established with digital technology for librarians recording the learning opinions and experience exchange so as to enhance librarians' professional growth. It would not simply assist librarians in the promotion of professional growth and job satisfaction, but could further insert more vitality to a library to transform individual knowledge into organizational knowledge through knowledge management to implement the goal of librarians' professional growth and enhance the growth and progress of a library.
3. The human resource management of a library should cover learning policies, which should be regulated in details, including the policy to support continuing education with digital technology, absence for education training courses with digital technology or formal learning activities, provision of financial support, and opportunities for career development. Besides, the participation in continuing education with digital technology is listed in the evaluation for promotion and position adjustment, and librarians with positive learning should be rewarded and praised. Those are powerful incentives. Consequently, definite learning policies are the effective mechanism to facilitate librarians applying digital technology to continuing education. Without them, applying digital technology to continuing education would not be implemented in spite that librarians present strong learning motivation.

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Effects of the Application of Computer Multimedia Teaching to Automobile Vocational Education on Students' Learning Satisfaction and Learning Outcome

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ABSTRACT

Along with the change in computer technology, the application of multimedia assisted teaching to education and research plays a critical role with the popularity of computer technology and the diverse development. Multimedia assisted teaching materials could assist teachers in teaching as well as enhance students' autonomous learning that computer multimedia teaching has become an alternative teaching tool beyond traditional learning. With quasi-experimental study, 216 students in the automobile applied technology opened by a vocational college in Shanghai, are proceeded 16-week (3 hours per week for total 48 hours) experimental teaching. The research results show positive relations between 1.virtual reality technology and learning satisfaction, 2.virtual reality technology and learning outcome, and 3.learning satisfaction and learning outcome. According to the results, suggestions are proposed, expecting to provide automobile vocational education students with the situation close to real life acquiring required skills, knowledge, or behavior through learning processes to cultivate the automobile service talents with comprehensive technology.

Keywords: virtual reality technology, vocational education, learning satisfaction, learning outcome

INTRODUCTION

The application of multimedia assisted teaching to education and research plays a primary role with the changing computer technology. Multimedia assisted teaching materials could assist teachers in the teaching and enhance the autonomous learning of students who could constantly and repeatedly review and practice unfamiliar contents to achieve the mastery learning. For this reason, computer multimedia teaching is constantly promoted; the popularity and multiple development of computer technology rely on the function of multimedia. In this case, teaching and multimedia also present critical effects. "Computer multimedia teaching" therefore becomes the traditional learning as well as a teaching assisted tool. In terms of education, computer multimedia teaching could effectively enhance teaching quality to break through the limits of time and space as well as receive immediate learning effect to assist in traditional teaching and have learners present multiple learning and innovation capability. The application of multimedia and the Internet as well as the development of new knowledge could manifest teaching quality.

Along with the development of network, intelligence, electronics, and information, automobile has been developed from transportation to exchange tools. The number of automobile in China reached 0.217 billion by 2017 which enhanced the rapid development of new-energy automobile and provide huge opportunities for automobile after-service markets. In the macro environment, automobile service industry proposes higher requirements for automobile service talents. In addition to grasping the knowledge of automobile internal structure, automobile

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Contribution of this paper to the literature

- As the large effect of the interface design refinement of virtual reality materials on learning outcome, detailed revisions and suggestions could be acquired after several times of user tests to gradually refine the interface design and interaction operation.
- Teachers integrating virtual reality technology and changes into course design and present diversified teaching methods could assist in enhancing students' learning intention and further promote the learning outcome.
- Properly opening some departments for university-level education could enhance the technical profession of vocational graduates. Besides, industry-university cooperation for students' internship or the opening of industry-university cooperation classes could conform to the requirements of local industries and allow students studying for the purpose of application to engage in relevant industries after the graduation.

service talents have to grasp automobile maintenance knowledge and follow the development of maintenance equipment, especially adequate knowledge reserve, to conform to the requirements for the motorized, intellectual, and networking development trend of automobile. In this case, it is necessary to cultivate automobile service talents with comprehensive techniques and stronger practice capability. This study therefore focuses on the effect of applying computer multimedia education to automobile vocational education on students' learning satisfaction and learning effectiveness. It is expected to enhance automobile vocational students' required skills, knowledge, or behaviors in the learning situation created with computer multimedia education close to real environment to cultivate automobile service talents with comprehensive techniques.

LITERATURE AND HYPOTHESIS

Computer Multimedia Teaching

Ab Aziz and Siang (2014) pointed out multimedia as being able to process texts and media of graphics, images, audio, animation, or video under the same working environment through the integration of computers (Lan et al., 2015). It implied to the program presentation with the combination of two or more than two different media to present static and dynamic sound and light effects (Maruping, Bala, Venkatesh, & Brown, 2017). Freina and Ott (2015) explained that "multimedia" did not simply present single message diversely but could complementarily apply various types of media to have the integrated effect exceed the independent application of media. Lan et al. (2015) referred it as an education concept as well as the teaching process directly applying computer communication model to present teaching materials and control individualized learning environment (Lan, 2015). The characteristics of image and audio integrated by interactive computer multimedia teaching with communication and media technology have diverse and open learning environment further enhance the role of computer multimedia assisted teaching technology in educational reform (Lan et al., 2015). Traditional computer multimedia assisted teaching is limited to drawing ability and merely transmitting meanings with texts or simple graphs to result in teaching outcomes being hard to break through and enhance. Since the emergence of computers and recorders, traditional computer multimedia assisted teaching could combine the sound and light effect of tape recorders with the process ability; and, multimedia computer assisted teaching systems combining computers with slide projectors and projectors also enhance computer multimedia assisted teaching entering the multimedia era (Lan, 2014).

Referring to Huang, Liaw, and Lai (2016), computer multimedia teaching used to be measured with law of effect, law of continuity, and law of practice.

(1) Law of effect: Instructors should provide proper feedback for learners' responses. Correct learning should provide positive reinforcement to develop encouragement function; on the contrary, negative reinforcement is provided for the suppression.

(2) Law of continuity: To enhance the function and develop the effect, feedback should present "immediateness", providing immediate feedback for learners' responses that the closer responses and feedback would result in larger effect.

(3) Law of practice: Instructors should provide opportunities for repeated practice till learners could provide correct answers in the shortest time to achieve the mastery.

Vocational Education

Ali, Ullah, Alam, and Rafique (2014) pointed out different names for vocational education, such as "further education" or "technical education" in UK, "vocational training" in Germany, "industrial education" or "career education" in the USA, "industrial education" and "production education" in Japan, and "polytechnic education" in Russia. Martins, Oliveira, and Popovič (2014) regarded it as a highly professional technical education, aiming to cultivate advanced professional talents of technicians and engineers. Griffin et al. (2017) regarded higher vocational education in China was the important composition of higher education, aiming to cultivate high-level technicians required for the economic society, especially being able to solve technical problems in the first-line production process. Being affected by globalization, technology is rapidly advanced that school education can no longer meet the requirements of industries. To cope with time change and global technology division, vocational education reform has been positively preceded in the world, such as integrating education and vocational training with employment department, completing vocational certificates close to employment market, revising vocational education regulations, and promoting industry-university cooperation (Kuksa & Childs, 2014), to cultivate cross-nation talents. Vocational education change requires the cultivation of students' key competency and, more important, inspires modernization capability for a modern person in the 21st century, which should be specially emphasized in all-level education.

Learning Satisfaction

In learning courses, learners' desires and needs being satisfied and achieved in the learning process is regarded as learning satisfaction (Kim, Son, & Han, 2016). Wijnants, Van Erum, Quax, and Lamotte (2015) pointed out learning satisfaction as a major item to measure learning result; in addition to students, teachers, curricula, and learning environment were the factors in student satisfaction. Nawaz et al. (2014) regarded learning satisfaction as students being "satisfied" by feeling happy or presenting positive attitudes towards learning activity and "dissatisfied" by feeling unhappy or negative attitudes. Bhagat, Liou, and Chang (2016) considered learning satisfaction as students' good perception or positive attitudes generated by favoring the course in the participation in learning activity. Shen, Ho, Kuo, and Luong (2017) explained learning satisfaction as the perception or attitudes generated in involving in favorable learning processes to induce individual motivated learning, persistent learning, and positive learning attitudes to eventually satisfy individual needs and expectation. Shafer, Carbonara, and Popova (2014) regarded the interaction between internal subjective perception and external learning as learning satisfaction. Shi (2017) indicated learning satisfaction that learning was to enhance the interests in learning courses and positive learning attitudes towards learning activities to satisfy learners' perceived needs and individual learning needs in the learning process.

Referring to Shen et al. (2017), learning satisfaction contains teachers' teaching and curriculum & environment in this study.

(1) Teachers' teaching: Teachers' professional knowledge, methods to solve students' problems, preparation for courses, teaching methods, teaching attitudes, interaction with students, and understanding students' individual needs would assist in promoting students learning satisfaction.

(2) Curriculum & environment: Learners present interests on and enhance the positive attitudes towards the content and behavior of learning activity.

Learning Outcome

A more persistent behavioral result through learning processes is regarded as learning outcome (Lan et al., 2015). Ratna and Mehra (2015) regarded learning outcome as the indicator to evaluate teaching and measure learners' learning result. Wei, Peng, and Chou (2015) proposed to measure with different indicators, including learning satisfaction, self-evaluation, learning interests, performance, and experience, as well as the learning behavior and learning results of the evaluation and participation in learning activities. Daggubati (2016) pointed out correct learning methods, good learning habits, and positive learning attitudes as the essential conditions to enhance students' learning efficiency. Wamba, Bhattacharya, Trinchera, and Ngai (2017) defined learning outcome as learners being able to change the professional knowledge and skills in the learning activity. Ryan (2015) regarded "skill" as the most important learning outcome that the better learning outcome, the better performance. Kourouthanassis, Boletsis, Bardaki, and Chasanidou (2015) indicated that learning outcome was the learning result, with direct and positive effects, presented on various evaluation and tests of learners after completing the learning process. Schuster et al. (2014) referred learning outcome to certain evaluation performance of learners after a period of learning activity. Kim et al. (2016) pointed out learning outcome as the expectation of what a learner learned, understood, and could describe after a period of learning processes. Lan, Kan, Sung, and Chang (2016) regarded learning outcome as learners' learning performance, including formative and summative evaluation results. Accordingly, learning outcome, referring to Lan et al. (2016), is measured with single dimensions, including test performance, schedule completion time, and term performance, in this study.

Relationship between Computer Multimedia Teaching and Learner Satisfaction

Mütterlein and Hess (2017) pointed out computer multimedia teaching as teaching activities not being restricted to time and space, allowing learners actively receiving information and achieving learning goals at any time. Besides, multimedia assisted teaching integrated, systemized, and organized texts, pictures, video, images, and animation into computers to satisfy learners accepting visual and hearing information technology changes to effectively enhance learner satisfaction. Freina and Ott (2015) mentioned that multimedia assisted teaching was affected by the design principle of programmed teaching, leaner-centered, behavioral goal oriented, and presented contents step by step to achieve learner satisfaction with constantly repeated practice through stimulation responses and immediate reinforcement. Computer multimedia teaching could provide multiple sensory stimulation, attract children's attention through vivid pictures, text symbols, and sound, as well as enhance learning interests and deepen learning impression (Lan, 2015). Bhagat et al. (2016) described that computer multimedia teaching provided students with opportunities to self-grasp learning schedule and achieve learning satisfaction from feedback. From above literatures, the following hypothesis is inferred.

H1: Computer multimedia teaching presents positive correlations with learner satisfaction.

Relationship between Computer Multimedia Teaching and Learning Outcome

Huang et al. (2016) regarded multimedia as an effective tool to fulfill situated teaching, develop stories with connection, and induce learner interests through careful design so that learners could reflect the learning process in the operation process and contact more accidental possibilities in the looping execution. Such teaching design normally could achieve the goals of cognition, affection, skills, and life education. Meanwhile, as the teaching is preceded through games, it could enhance learners' learning intention and learning outcome. Kourouthanassis et al. (2015) indicated that multimedia assisted learning courses should be integrated into relevant work to integrate knowledge into learning situations and have learners interact and actively participate in learning activities from observation, imitation, and learning as well as knowledge and skills to achieve learners' interactive relationship between simulated situational activities and learning situations (Lan et al., 2015). Daggubati (2016) concluded that multimedia assisted learning could induce students' learning motivation, fulfill learning initiative, and grasp the interaction with environment to achieve skill learning and effectively enhance learning outcome. Accordingly, the following hypothesis is inferred.

H2: Computer multimedia teaching shows positive correlations with learning outcome.

Relationship between Learning Satisfaction and Learning Outcome

Shen et al. (2017) regarded various behaviors, attitudes, and perception of learning activity to present the preference of the learning activity as learning satisfaction; and, students with higher learning satisfaction would present better learning outcome, which therefore was a primary goal of distinct learning. Lan et al. (2016) discussed the relationship between learning satisfaction and learning outcome and revealed the remarkably positive effect of learning satisfaction on learning outcome. Juan and Chao (2015) found out the moderately positive correlation between learning satisfaction on learning outcome of students in PE classes in elementary schools in Taipei City and New Taipei City. Shi (2017) proved the notably positive correlations between students' learning satisfaction and learning outcome in swimming lessons. Jung and Han (2014) discussed G6 students in an elementary school and found out the significantly positive correlation between learning outcome and learning satisfaction. The following hypothesis is then inferred from above literatures.

H3: Learning satisfaction reveals significantly positive relations with learning outcome.

SAMPLE AND MEASURING INDICATOR

Research Sample and Object

Aiming at the automobile applied technology opened by a vocational college in Shanghai, 216 students are proceeded the 16-week (3 hours per week for total 48 hours) quasi-experiment. The retrieved data are analyzed with SPSS, and Regression Analysis and Analysis of Variance are applied to test various hypotheses.

Reliability and Validity Test

Validity refers to a measuring tool being able to really measure what a researcher intends to measure. Generally speaking, validity is divided into content validity, criterion-related validity, and construct validity. The items used in the questionnaire are referred to domestic and international researchers' items, and a pretest is preceded before

Table 1. Analysis result of overall linear structural relation model

Evaluation item	parameter/evaluation standard		result	t
preliminary fit criteria	Computer multimedia teaching	law of effect	0.713	12.16**
		law of continuity	0.708	10.33**
		law of practice	0.723	13.41**
	learning satisfaction	teachers' teaching	0.744	15.27**
		curriculum & environment	0.756	16.12**
	learning outcome		0.769	18.44**
fit of internal structure of model	Computer multimedia teaching→learning satisfaction		0.863	33.91**
	Computer multimedia teaching→learning outcome		0.849	31.63**
	learning satisfaction→learning outcome		0.827	28.33**
overall model fit	X2/Df		1.177	
	GFI		0.982	
	AGFI		0.927	
	RMR		0.007	

Note: * stands for p<0.05, ** for p<0.01, and *** for p<0.001

the distribution of formal questionnaire that the questionnaire presents certain content validity. Virtual reality technology, learning satisfaction, and learning outcome are tested the causal relationship with Linear Structural Relations, and the data registration is based on the correlation coefficient matrix of above observed variables. The analysis result with Linear Structural Relations Model shows the overall model fit reaching the reasonable range that it presents favorable convergent validity and predictive validity. Item-to-total correlation coefficients are used for testing the construct validity of the questionnaire, i.e. reliability analysis, and the acquired item-to-total correlation coefficients are applied to judge the questionnaire content. The item-to-total correlation coefficients of the dimensions are higher than 0.7, revealing certain construct validity of the questionnaire.

To further understand the reliability and validity of the questionnaire, reliability and validity analyses are further preceded. The higher Cronbach's α presents the better reliability. The formal questionnaire is developed according to the standards, and the measured Cronbach's α appears in 0.70~0.88, obviously conforming to the reliability range.

EMPIRICAL RESULT ANALYSIS

LISREL Model Indicator

LISREL (linear structural relation) model, combining factor analysis and path analysis in traditional statistics and adding simultaneous equation in econometrics, is the research tool being able to simultaneously calculate multi-factor and multi-casual path. The goodness-of-fit of the model could be evaluated from preliminary fit criteria, overall model fit, and fit of internal structure of model.

The data results are organized in **Table 1**. Preliminary fit criteria, fit of internal structure of model, and overall model fit are explained as following.

From **Table 1**, the dimensions of Computer multimedia teaching (Law of effect, Law of continuity, Law of practice) could significantly explain Computer multimedia teaching ($t>1.96$, $p<0.05$), two dimensions of learning satisfaction (teachers' teaching and curriculum & environment) could remarkably explain learning satisfaction ($t>1.96$, $p<0.05$), and the explanation of learning outcome reaches the significance ($t>1.96$, $p<0.05$). Apparently, the overall model presents favorable preliminary fit criteria.

In regarding to internal structure of model, Computer multimedia teaching shows positive and remarkable correlations with learning satisfaction (0.863, $p<0.01$), Computer multimedia teaching reveals positive and notable correlations with learning outcome (0.849, $p<0.01$), and learning satisfaction appears positive and significant correlations with learning outcome (0.827, $p<0.01$) that H1, H2, and H3 are supported.

The overall model fit standards $\chi 2/Df=1.177$, smaller than the standard 3, and RMR=0.007 reveal that the results of $\chi 2/DF$ and RMR are appropriate. Besides, chi-square is sensitive to sample size that it is not suitable for directly judging the fit. However, the overall model fit standards GFI=0.982 and AGFI=0.927 are higher than the standard 0.9 (the closer GFI and AGFI to 1 showing the better model fit) that this model presents better goodness-of-fit indicators.

CONCLUSION

The research results show that current computer multimedia teaching presents the advantage of situation creation and the characteristics of interface visualization and element reusability. Teaching designers could flexibly apply technology to present teaching strategies. Applying computer multimedia teaching to automobile education could research & develop and design teaching materials in the media production, including point organization, pictures, photos, close-up pictures, continuous replay, subtitles, slow motion, distance switch, color effect, dynamic effect, sound effect, fast turning effect, and background music. Besides, the assistance of pictures and photos could specify lecturing contents that static pictures or photos could be timely added in dynamic audio teaching materials, e.g. relevant photos provided by teachers. Network data provided in computer multimedia teaching are presented with objects and combined with image metaphors to thorough utilize scenario memory in the space and provide external resources for students' further learning. It could also provide texts or categories for search. When matching with processes, students could better know what data to read in which step. It is better to switch scenario so that students feel to enter different levels, without wasting time on data irrelevant to tasks, and to relatively enhance student satisfaction and learning outcome.

RECOMMENDATIONS

Aiming at the research results and findings, the following practical suggestions are proposed in this study.

1. As the large effect of the interface design refinement of virtual reality materials on learning outcome, detailed revisions and suggestions could be acquired after several times of user tests to gradually refine the interface design and interaction operation. For instance, the automobile vocational education courses are detailed, huge, and complicated that the information transmission and interaction should be carefully planned the information presentation and students' participation feedback. Various angles could be applied to the switch of close up and distance switch to provide students' with clear ideas for the overall allocation and local pictures in automobile service processes. Perhaps the production different from general teaching could be applied to present with vivid and active methods so as to induce students' learning interests.
2. From the aspect of enhancing students' learning satisfaction, teachers' course contents and professionalism are the key factors. In this case, teachers integrating virtual reality technology and changes into course design and present diversified teaching methods could assist in enhancing students' learning intention and further promote the learning outcome.
3. In addition to Tian Sino-German University of applied Science, the higher vocational colleges in China still stay at college-level education. In face of the society with rapidly developed technology, college-level education could hardly conform to the skill requirements of industries for talents. Properly opening some departments for university-level education could enhance the technical profession of vocational graduates. Besides, industry-university cooperation for students' internship or the opening of industry-university cooperation classes could conform to the requirements of local industries and allow students studying for the purpose of application to engage in relevant industries after the graduation.

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Does Repetition of the Same Test Questions in Consecutive Years Affect their Psychometric Indicators? – Five-year Analysis of In-house Exams at Medical University of Warsaw

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ABSTRACT

Aim of study: Evaluation of the re-used test questions on the impact of psychometric indicators of test items in examinations in cardiology in Physiotherapy at the Medical University of Warsaw (MUW).

Materials and Methods: A case study based on analysis of 132 five-option (528 distractors) multiple-choice questions (MCQs) developed at MUW included in five in-house exams. Questions repeated at least twice during the period considered and constituted 42.4% of all MCQs. Each MCQ was assessed on the basis of the following three indicators: difficulty index (DI), discrimination power (DP), and the number of non-functioning distractors (N-FD). The change in psychometric indicators of test items was assessed using Krippendorff alpha coefficient (α_k).

Results: Together with each MCQs repetition, a decrease in the number of questions that would maintaining the analogical DI value towards the initial level of easiness was observed. However, the level of DI compliance was significantly higher, even when there were five consecutive repetitions (coefficient α_k for the consecutive repetitions was 0.90, 0.85, 0.78 and 0.75). N-FD number in consecutive repetitions remained on a satisfactory level (good and very good compliance), although there was a significant decrease in this range when there were three or more repetitions (coefficient α_k was 0.80, 0.69, 0.66 and 0.65, respectively). Whereas the level of similarity as for DP for consecutive repetitions was significantly lower in comparison with those noted for DI and DE (DP coefficient α_k was 0.28, 0.23, 0.25 and 0.10, respectively).

Conclusions: The observed change in the initial values of psychometric indicators together with consecutive use of the same MCQs confirms the examiners' concerns as for the progressive wear of the bank of test questions. However, the level of psychometric MCQs values loss, especially in the area of the easiness and the number of non-functioning distractors was not drastic. It appears that the level of MCQs spread among students of consecutive years is not too high, at least within two consecutive years.

Keywords: educational measurement, test questions, differentiation power, ease, health sciences, students

BACKGROUND

"May I use the same test question during another exam round"? Every teacher who applies tests in their teaching as a method that checks students' knowledge faces this question while evaluating their students' educational

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Contribution of this paper to the literature

- Multiple use of the same MCQs results in reduced differentiation power of examination tests prepared using the same pool of questions.
- By limiting the use of the same pool of MCQs more than twice in a row it is possible to maintain an adequate number of functioning distracters, the difficulty and the differentiation power of MCQs from the bank of test questions.
- The rotational and rational use of the limited resources of MCQs while preparing and administering an in-house exam may extend the "life" of the bank of test questions.

achievements. Long-term analyses of test question pools offer a closer look at how psychometric indicators of test questions, particularly those used more than once in subsequent rounds of in-house exam, change over the years.

For an average teacher it is difficult to create test questions (e.g. multiple-choice questions (MCQs) with very good psychometric indicators. The necessity to write new MCQs each year poses an additional difficulty. The question as to whether to recycle questions is an issue any organization administering tests or examinations must address (Kim, 2013). Once MCQs are re-used, the probability of their content becoming publicly available is higher, which gives advantage too those who have access to it (And in the age of the Internet, once they do leak out, there's a good chance that someone will post the information online (Somin, 2011)). Additionally, there is also concern about question repetitions in situations when a student failed their exam and is obliged to retake it.

Therefore, in many cases re-using MCQs is required on the grounds of the necessity to provide comparable conditions of evaluation (equivalence in consecutive rounds in the scope of fairness and validity of measurement) (Yang, Lee, & Park, 2018). In the literature, data on the subject of the influence of sharing banks of test questions can be found. It has been demonstrated that public access to such banks does not have to negatively influence fairness and validity of an exam (Wagner-Menghin, Preusche, & Schmidts, 2013; Wood, 2009; Wood, St-Onge, Boulais, Blackmore, & Maguire, 2010; Yang et al., 2018). However, despite these reports, there is currently no consensus in the field of unambiguous evaluation of the influence of sharing content of questions on the effectiveness of examination procedure (Yang et al., 2018).

Assessing students using tests including questions that have already been used, bears a risk that responses obtained in this way will not comply with the criteria of good educational measurement (T. J. Wood, 2009). It may be assumed that the more often a question is asked, the more plausible it will be that this question will become a part of the so-called "public domain" and will as such bring additional benefits to students who had access to such questions. Additional problem associated with re-using the MCQs it is the occurrence of practice effects in the group of exam retaking students who are exposed to the questions which they had already known from the first exam. (O'Neill, Sun, Peabody, & Royal, 2015). These factors may contribute to an increase in the ease and reduced varying ability of the test. In the literature the described above phenomenon of changes in the properties of individual test items after repeated exposure is defined as Item Parameter Drift (IPD) (Krause, 2012). The main parameter applied in the detection of IPD is the increase in the easiness of a question. The data concerning the easiness of the level of repeated questions (retest) published so far show that even though a re-used item is characterized by a greater easiness (Cates, 1982; Hertz & Chinn, 2003; O'Neill, Lunz, & Thiede, 2000; Raymond, Neustel, & Anderson, 2009; Wood, 2009), this change is slight and remains within the limits of error measurement for a given test (O'Neill et al., 2000). Moreover, the results published by O'Neill et al. (2015) on the influence of the re-used set of test questions during the American Board of Family Medicine's certification examination show that even if in some cases using test questions again may bring benefits to the test takers, the generally observed change is by and large connected with guessing than with the prior knowledge of questions.

Due to the lack of possibility of constant supply of new MCQs to the bank of test questions, it seems rational to include control of psychometric properties of MCQs in the procedure of ensuring the quality of evaluation. The quoted findings allow to assume that re-using the same test question in another evaluation round should not significantly worsen the psychometric properties of MCQs. Yet it seems appropriate to ask after how many times of using a given MCQ, its psychometric properties worsen so much that it fails to fulfil the assumed criteria. Answering this question requires compiling and assessing psychometric properties applied for MCQs and that should not be solely limited to the difficulty index (DI). Evaluation of the bank of test questions should include also assessment of the discrimination power (DP) and the number of non-functioning distractors (N-FD). Following the changes that take place in psychometric properties of MCQs in consecutive sessions or test rounds, should give an opportunity of inclusion of defence mechanisms that would protect against the excessive use of questions and lowering the quality of assessment. Additional advantage of carrying out such control could be applying the results of test questions evaluation in the improvement of faulty or "overused" MCQs (Considine, Botti, & Thomas, 2005).

Based on available premises in the literature, three hypotheses, verified in the course of the study, have been formulated:

1st hypothesis – Re-using MCQs in subsequent years does not influence DI and N-FD indicators.

2nd hypothesis – Re-using MCQs in subsequent years negatively influences DP indicators.

3rd hypothesis – Indicators DI, N-FD and DP are at a similar level regardless of single or multiple use of MCQs.

AIM OF STUDY

The present study aimed to assess the influence of re-used test questions on the change in psychometric indicators of test items (DI, N-FD, and DP) in examinations in Cardiology in Physiotherapy at the Medical University of Warsaw (MUW).

MATERIAL AND METHODS

Context

The test was carried out at MUW that is one of the biggest medical universities in Poland. Among other faculties, MUW educates students at the Faculty of Physiotherapy, where studies are conducted on the BA as well as MA levels. Within the two-year programme of MA studies, one of nine subjects of specialized education during the first year is functional diagnostics and scheduling rehabilitation in cardiology. Learning outcomes in this subject include issues connected with the structure, functioning and pathological changes in blood circulation and structural changed caused by the illness. This knowledge is then applied in functional diagnostics and in physiotherapeutic treatment. As part of the subject, students have seminars in groups of up to 20 people (10h), and also clinical exercises in groups of 6 people (30h). Additionally, students are obliged to undergo internship in the field of clinical physiotherapy in cardiology (20h).

The level of assumed learning outcomes for students is evaluated using a test comprising 50 MCQs elaborated and developed by the lecturers from Cardiology Clinic, Department of Physiotherapy, 2nd Faculty of Medicine MUW, which is a unit responsible for teaching this subject. MCQs established for the purpose of the exam are evaluated by the head of the clinic who makes the final approval of the task pool included in the bank of test questions. The bank of tasks is administered by Examinations Office which also organizes all the exams at the MUW. The course and the conditions of student assessment are described in the procedure and are regulated by the Rector of the MUW (Decree No. 93/2014).

Data Collection

Pool of test questions prepared for exams in the field of knowledge in cardiology between the academic years of 2008/09 and 20212/13 included 132 five-option MCQs (516 distractors), 76 of which were MCQs (57.6%) that were used once only, and 56 MCQs (42.4%) used at least twice. The percentage of MCQs not used in testing before was changeable and was 100% (2008/09), 62% (2009/10), 28% (2010/11), 32% (2011/12), and 36% (2012/13).

In the tested period, 100 new physiotherapy students took the cardiology exam each year (498 students in total throughout a five-year period). Each student could take the test once only. The exam was carried out in a traditional, pen and paper form. The conditions during the exam were comparable as far as time is concerned (60 minutes), the number of test versions (2 versions different in the order of questions in a set) and the number of test takers. Calculating score was done automatically, using a test card reader (scanner) and computer software TESTY version 7 ("Testy komputerowe", Copyright © 1994-2014 by Sławomir Zalewski, licence issued for MUW).

Psychometric Indicators

While evaluating psychometric properties of MCQs, a concept based on the measurement evaluation included in Classical Test Theory (also known as classical true score theory) was applied. CTT is a simple linear psychometric model describing how measurement errors may influence the observed result (Schuwirth & van der Vleuten, 2011). Traditionally, CTT uses two indicators in evaluating psychometric measurement in form of a test: difficulty index (DI) and discrimination power (DP) (Erguven, 2013). Additionally, for every MCQ from the pool of questions, there was also a number of non-functioning distractors (N-FD) (Tarrant, Ware, & Mohammed, 2009).

Statistical Analysis

In evaluating changes in the values of individual psychometric indicators for 53 MCQs which were used during a five-year period at least twice, Krippendorff alpha coefficient (α_k) was used (Krippendorff, 2012). Coefficient α_k developed to measure the agreement among observers, coders, judges, raters, or measuring instruments. α_k emerged in content analysis but is widely applicable wherever two or more methods of generating data are applied

Table 1. Compliance of difficulty index value for the correct option and the frequency of selection of the distractors for questions with different number of repetitions

Questions with a number of repetitions	Krippendorff alpha coefficient		
	Difficulty index	Discrimination power	Number of non-functioning distractors
Twice	0.90	0.28	0.80
Three times	0.85	0.23	0.69
Four times	0.78	0.25	0.66
Fivefold	0.75	0.10	0.65

Table 2. Change of psychometric indicators' value for MCQs repeated twice or three times

Psychometric indicators	1st vs 2nd			1st vs 3rd		
	Increase	No change	Reduction	Increase	No change	Reduction
Difficulty index	32 (57%)	6 (11%)	18 (32%)	23 (68%)	2 (6%)	9 (27%)
Discrimination power	27 (48%)	3 (5%)	26 (47%)	15 (44%)	0 (0%)	19 (56%)
Number of non-functioning distractors	8 (14%)	40 (72%)	8 (14%)	8 (23%)	20 (59%)	6 (18%)

to the same set of objects, units of analysis, or items. This coefficient is the most universal compliance coefficient as it has no limitations concerning: type of a measurement scale, value number / category within scale, number of repeated measurements and the minimum number of evaluated cases. Its undoubted advantage lies in its resistance to the lack of data. α_k coefficient assumes values between -1.00 and +1.00, whereas 0.00 means compliance with the level of cases and +1.00 means perfect compliance (Krippendorff, 2012).

Additionally, the number of MCQs was assessed for which psychometric indicators were altered after two and three repetitions. Values of psychometric indicators for 76 MCQs were established, if MCQs were used once only, and these values were compared with the values of questions used ≥ 2 times. Due to the different number of people in groups and no regular spread accessible for comparison of the pool of questions used once and twice, a non-parametric Mann Whitney U test was used and the effect size was evaluated by calculating biserial correlation coefficient (r_b). The conditions of using Mann Whitney U test were checked by assessing the similarity of dispersion of a dependent variable in both compared groups (Ansari-Bradley dispersion test) (Nachar, 2008).

STATISTICA software, version 12.5, was used in calculations, together with an additional module "Zestaw PLUS" (StatSoft, Inc.) in compliance with the licence issued for MUW. For each analysis, the level of statistical significance assumed *a priori* was $\alpha = 0.05$.

RESULTS

Verification of the 1st Hypothesis

The analysis of value similarity indicators for the repeated questions shown that there is a very good or good compliance in this area for DI and N-FD indicators (**Table 1**). In case of DI indicators, with every repetition of MCQs, a decrease in the number of questions maintaining the analogical DI value was observed in comparison with the initial level of easiness. However, the level of DI compliance was high enough even with five consecutive repetitions ($\alpha_k > 0.70$). The N-FD number in consecutive repetitions remained on a satisfactory level (good or very good compliance), although there was an observed significant drop in this area for three or more repetitions (**Table 1**).

While evaluating the influence of a re-used MCQ on psychometric indicators' value, the change in the easiness was checked as well as the number of distractors between the first and the second use (1st vs 2nd), and between the first and the third use (1st vs 3rd) (**Table 2**). An increase in the DI value was observed for a significant percentage of the repeated MCQs both while comparing the 1st vs 2nd and 1st vs 3rd (DI increase for 57% MCQs for two repetitions and 68% MCQs for three repetitions). Whereas in case of changing the number of ineffective distractors while comparing 1st vs 2nd , 72% MCQs remained without a change, and for 1st vs 3rd 59% MCQs.

Verification of the 2nd Hypothesis

Findings concerning DP indicator remain in contrast to these as there was no or very little compliance. For consecutive repetitions, coefficient α_k was significantly lower in comparison with those noted for DI and DE. Also, a low value of α_k noted for questions with five repetitions was characteristic (**Table 1**). Additionally, a lower differentiating ability was noted for MCQs while comparing 1st vs 2nd and 1st vs 3rd (lowering the DP value for 47% MCQs for two repetitions and for 56% MCQs for three repetitions) (**Table 2**).

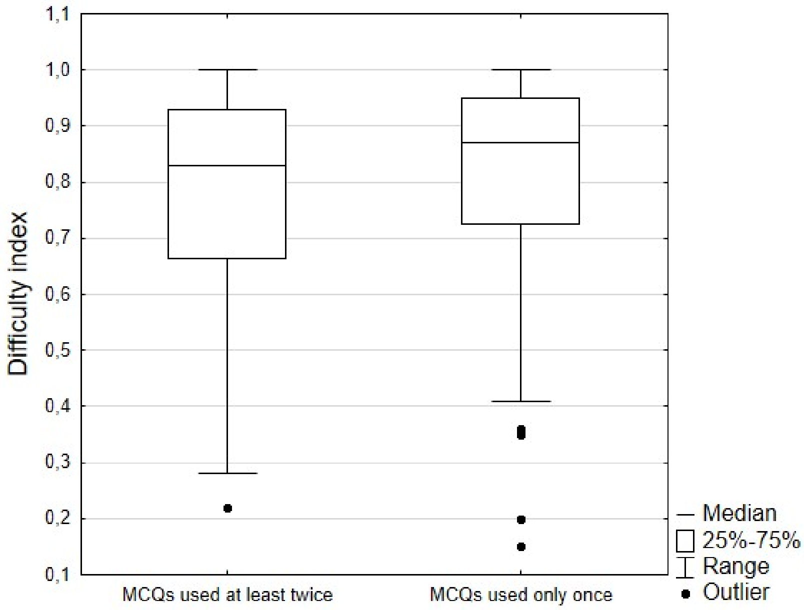

Figure 1. Comparison of the difficulty index value calculated after the first use of the MCQs pool and used at least twice as opposed to those used once only

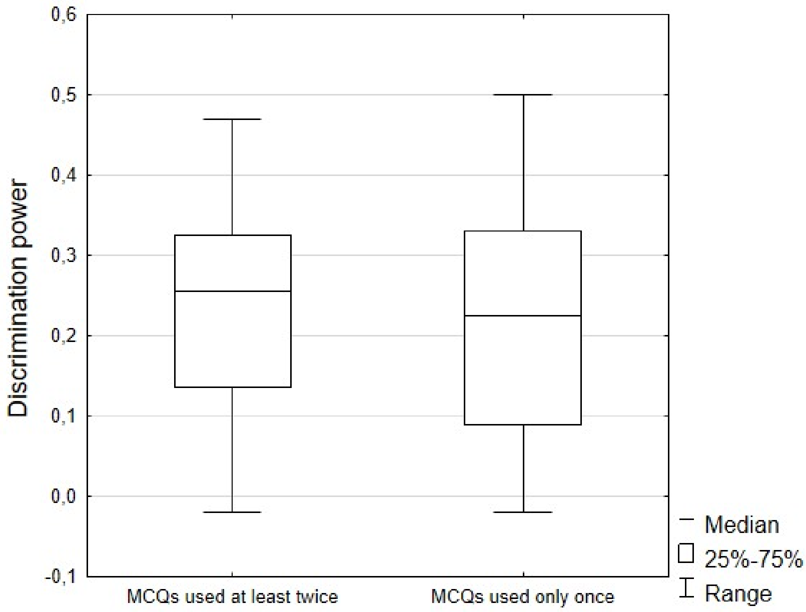

Figure 2. Comparison of the discrimination power value calculated after the first use of MCQs pool and used at least twice as opposed to those used once only

Verification of the 3rd Hypothesis

While comparing the level of easiness of MCQs for questions repeated at least twice and those used once only, there was no statistically significant differences noted between these two pools of MCQs (Mann Whitney test, U=1723.0, P=0.365, r_b=0.09; **Figure 1**). Similarly, there were no differences while comparing discrimination power (Mann Whitney test, U=987.5, P=0.558, r_b=0.07; **Figure 2**). Additionally, no statistically significant differences were noted while comparing the number of non-functioning distractors (Mann Whitney test, U=819.5, P=0.849, r_b=0.02; **Table 3**).

Table 3. Comparing the number of non-functioning distractors calculated after the first use of an MCQs pool that were used at least twice as opposed to those used once only

Number of non-functioning distractors	MCQs used at least twice		MCQs used only once	
	N	%	N	%
Four	15	26.8%	11	32.4%
Three	25	44.6%	11	32.4%
Two	10	17.9%	4	11.7%
One	5	8.9%	4	11.7%
Zero	1	1.8%	4	11.7%

DISCUSSION

Despite the large number of studies and guidelines for the proper creation and development of MCQs (Case & Swanson, 2002) our current knowledge of "aging" of the test questions which were used several times for evaluation of the same or different student groups is insufficient (O'Neill et al., 2015). Although there are research results on the influence of public availability of large banks of test questions (Gilmer, 1989; Park & Yang, 2015; Wagner-Menghin et al., 2013; Wood, 2009; Yang et al., 2018) on exam results, the conclusions from this type of research cannot be directly transferred to in-house exams, which are conducted on a much smaller scale than large country-wide standardized exams. Among teachers, there is a conviction that the use of the same MCQs for next year exam will contribute to an increase in its ease which will result in inflated scores.

Once the text of the MCQs is transferred from one student to another, it may become the cause of dishonesty, as some students have access to the items, while others do not. What teachers conducting in-house exam may do in order to lessen the risk connected with sharing the content of the questions? One possible solution is sharing the MCQs used so far with all students, so that all of them have equal chances (Somin, 2011). This strategy undoubtedly allows maintaining fairness of the exam, but at the same time increases workload, as each year a new set of MCQs needs to be prepared.

The obtained results confirmed authors' assumptions as to the change in value of psychometric indicators of MCQs after using them at least twice in different groups of students. Fulfilling the assumption that MCQs used ≥2 initially had similar values of psychometric indicators to the questions used once demonstrated that reused MCQ influenced on the values of the indicators in a manner which manifests in a decrease of compliance of obtained values of psychometric indicators. While in the case of the double use of an MCQ pool, the ease and the number of non-functional distractors retains a high degree of similarity to the first use, the next rounds in which the MCQs are exposed significantly influence the compliance of obtained indicator DI and N-FD values. The significant deterioration of compliance is also observed in case of indicator DP but in this case after the second use of an MCQ pool the compliance of registered values was significantly decreased for this indicator ($\alpha_k < 0.30$).

A more thorough assessment of changes in the value of three psychometric indicators for repeated MCQs allowed to determine the direction of changes in subsequent exposures of items in a new group of students. In all cases the double usage of MCQs had less negative impact on DI, DP and N-FD than three times usage of the same MCQs. The above findings show the existing relationship between the number of MCQ exposures and noted value of psychometric indicators.

The observations described above are related to the reuse of MCQs in different groups of students. Therefore, there is an opportunity to exchange information regarding examination questions between those groups. However, it is not known to which extent the used MCQs are remembered so well, they can be effectively passed to students taking examinations in consecutive rounds. The available literature provides us with some knowledge about the effects of subsequent exposure of the same candidate to tasks previously used in the evaluation. These findings refer to the situation when the content of the tasks on the first try was remembered and used by the same person during the retaking of the examination. It is therefore a scheme of repeated measurement on the same group of candidates (retest). Boulet, McKinley, Whelan, and Hambleton (2003) noticed that candidates retaking the exam using a standardized patient (clinical skills assessment) did not obtain significantly better or worse results in comparison to the first examination. Similar results were obtained by Raymond et al. (2009). On the other hand Wood (2009) noticed that students retaking an exam obtained higher scores but this findings applied to both the pool of new and reused questions. O'Neill et al. (2015) observed that the results obtained by the students retaking the examination were slightly better than received at the first approach. However, the estimated effect size for the difference in scores obtained for unique questions and reused questions was small (O'Neill et al., 2015). Also Swygert, Balog, and Jobe (2010) registered some growth in scoring obtained in retaken examination for the United States Medical Licensing Examination series Step 2 Clinical Skills. Greater number of received points did not however depend on whether or not the student knew the question (Swygert et al., 2010).

The above data, even though it represents measurements of the retest type, gives reason to believe that the repeated use of previously disclosed questions does not have to affect the increased results of the next evaluation. If the observed increase in results of retaken exams is similar in terms of new and reused tasks, it can be argued that the degree of the memorising of the questions is not as significant as it might appear. The differences observed at the MUW regarding the ability of differentiation and growth ease of MCQs between two and three times usage show that solutions protecting from the excessive use of the question bank should be introduced.

Certainly an important factor that could reduce the risk of excessive "aging" of questions is the use of tasks with high differentiation parameters and high efficiency. It is usually difficult to remember such questions in detail as far as the content of header (stem) and particular answer options are concerned. In addition, the introduction of new types of questions (such as Extended Matching Questions or Short Answer Questions) reduces the chance that the questions memorized by students will be a valuable source of information for subsequent student years. (Mujeeb, Pardeshi, & Ghongane, 2010; Oyebola et al., 2000).

Open banks of exam questions are published in numerous countries and every student can become familiar with their contents and thus prepare for the final exam or mid-term test (Considine et al., 2005; Hansen & Dexter, 1997; Park & Yang, 2015; Yang et al., 2018). It needs to be noted, however, that open task banks usually contain a few thousand of items (e.g. The Dutch Progress Test is in the public domain, but it contains over 10.000 items grouped in 19 disciplines and 17 categories (Tio et al., 2016)). Academic textbooks also use test questions as a teaching tool in order not to check knowledge but to teach (Masters et al., 2001). Thus, it seems that the presence of the "student market" should not discourage examiners from re-using MCQs. However, the conditions that in this case must be met are: (1) constant control of psychometric indicators of MCQs, (2) rotary and rational usage of available resources of the tasks bank and (3) creation of new types of questions which could be used in computer examination. Furthermore, the adding to the procedures of university assessment quality management the following principles: constant control and analysis of trends in changes of MCQ psychometric properties; the obligation of taking appropriate actions by test questions developers which should be aimed at improving operational efficiency of distractors and elimination of defective construction of MCQs. Some options include creating new test questions ever year or allowing a sufficient amount of time (2-3 years) between question re-use. Although there are several suggested solutions, the question as to whether test items should be reused and recycled remains an unanswered one (Kim, 2013).

LIMITATIONS OF STUDY

The main limitation of the presented case study was analysis of psychometric indicators of reused MCQs using the concept of evaluation of measurement described CTT. For more accurate description of the complex characteristics of the measurement characteristics of the hypothetical feature dominating the responses given in the test, the more appropriate would be the usage of a model based on Item Response Theory (IRT). However, at the item level, the CTT model is relatively simple. CTT does not invoke a complex theoretical model to relate an examinee's ability to success on a particular item. Instead, CTT collectively considers a pool of examinees and empirically examines their success rate on an item (Erguven, 2013). An important argument for the use in the presented work of psychometric indicators resulting from CTT is a small number of items. For the correct item parameters estimation suffice the number of items in the range of 200-500, whereas in the case of IRT generally required number is >500 items (Erguven, 2013; Hambleton & Jones, 1993).

CONCLUSIONS

The change of the output values of psychometric indicators together with the reuse of the same MCQs indicate a gradual wear of bank of test questions. On the one hand, after the double use, the degree of loss of the desired properties of psychometric MCQs within the ease and the number of non-functional distractors was small, contrasting with a clear reduction in power of differentiation. On the other hand, the three times used MCQs were characterized by already considerable deterioration of psychometric properties. It appears that the prevalence of MCQs contents among students of two subsequent student years is not large enough not to be able to use twice some of a pool of the same MCQs exams assessing the knowledge. It is necessary to continue studies with the aim to determine the impact of the reuse of the same MCQs however not year after year but every two or three years. Moreover, it is necessary to extend of the research and using a large number of items what would allow the use of non-linear modelling based on the IRT.

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Based on Environmental Education to Study the Correlation between Environmental Knowledge and Environmental Value

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ABSTRACT

Global warming has aroused international emphasis in past years. The improvement in global environmental problems is urgent, and the promotion of environmental education is an important route to enhance humans' environmental literacy and solve environmental problems. People have paid more attention to environmental education or environmental issues in management education, expecting to enrich people's environmental knowledge and environmental value through environmental education so as to change people's attitudes. In this case, people would naturally emphasize environmental issues, take behaviors beneficial to the environment, i.e. responsible environmental behaviors, particularly the environmental knowledge of the next generation, and cultivate the habit to protect the environment. Aiming at students of Central University of Finance and Economics, total 360 copies of questionnaire are randomly distributed, and 288 valid copies are retrieved, with the retrieval rate 80%. The research results show significant and positive correlations between 1.environmental education and environmental knowledge, 2.environmental knowledge and environmental value, and 3.environmental education and environmental value. According to such results, suggestions are proposed, expecting to find out the effect of environmental education on people's environmental knowledge and environmental value and have relevant environmental units find specific ways to strengthen the citizens' responsible environmental behaviors.

Keywords: environmental education, environmental knowledge, environmental value, action knowledge

INTRODUCTION

Most ethnic groups used to present "inexhaustible" opinions about and attitudes toward nature and environment. Such "inexhaustible" nature and environment provided survival, living, and even enjoyment for human beings, who had no idea about the source. Such unknown nature and environment offered humans with needs for survival and living (Fazli, Imani, Abedini, 2018; Singh, 2015; Romine, Banerjee, Barrow, Folk, 2012; Kamga et al., 2018; Elnashaie, 2018; Zhang et al., 2018; Marques & da Silva, 2017; Kopnina & Cocis, 2017). The lack of knowledge and technology had people rely on natural environment for the survival and living. The idea to rely on the "God" for survival and living became extremely strong. The first Earth Day reminded people that human behaviors seriously damaged the environment on the earth and threatened the survival of humans and other species. People, particularly consumers and developed countries, therefore were aware of the changes in the production and consumption habits. In other words, improper human behaviors were the cause of environmental pollution, and a lot of environmental problems were the by-product of people satisfying individual safety, comfort, status, power, effort saving, and joy. Such an idea inspired many behaviorists, who started to propose various technologies to correct human behaviors and protect the earth.

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Contribution of this paper to the literature

- Environmental education teacher training institutions should hold trainings and studies related to course planning, design, and integration for in-service teachers' environmental education study, cultivating in-service teachers' professional ability of environmental education research and development.
- When promoting environmental education, teachers should be induced the potential, affirm the efforts, and enkindled the insistence and passion for environmental education. Teachers would not give up the mission because of not being materially rewarded.
- In environmental education teaching process, students should be encouraged to present opinions aiming at various environmental problems and guided deeper discussions aiming at different types of environmental knowledge and value so that students could re-clarify and construct the environmental value through criticism and comparison.

People, in past years, have gradually paid attention to environmental education or environmental issues in management education, and consumers also stress more on the possible impact of purchase decisions on the environment. The government and public sectors have made a lot of efforts to enhance the development of environmental education, aiming to enrich the citizens' environmental knowledge and environmental value through environmental education to change the attitudes. People therefore would naturally emphasize environmental issues and take beneficial behaviors to the environment, i.e. responsible environmental behaviors, particularly the environmental knowledge and the environmental protection habit of the next generation. Although there are more environment-friendly products nowadays and more consumers present positive attitudes towards environmental issues and green consumption, the actual consumption is full of contradiction and inconsistency. Would the promotion of environmental education have people present responsible environmental behaviors? From the observation of the real society, the environment is worsening and environmental incidents happen endlessly, while people seldom develop responsible environmental behaviors. For this reason, this study intends to discuss the correlation among environmental education, environmental knowledge, and environmental value, expecting to find out the effect of environmental education on people's environmental knowledge and environmental value and have environmental units find specific ways to strengthen the citizens' responsible environmental behaviors.

LITERATURE AND HYPOTHESIS

Environmental Education

Pandit, Dhakal, and Polyakov (2015) proposed the essence of environmental education that humans should know the environment through education and present awareness and consciousness about the relationship between subjective desires & needs and the environment, as well as correct and reflect the attitudes towards and value of the pursuit and utilization of natural environment. Baumgartner (2014) specifically explained that environmental education was not simply to objectively know the environment, but objectively know and understand the relationship between humans' subjective desires & value and the environment as well as be aware of and cultivate how to self-constrain and self-reflect the permanent relationship between human survival & living and natural environment. Siew et al. (2015) indicated that the entire education essence and content should present science and humanity, especially the philosophy knowledge among natural environment, natural rules, and natural law. Pluess (2015) argued that environmental education should not simply focused on knowing the scientific knowledge of objective environment and the technique to deal with environment problems. Zorrilla-Pujana and Rossi (2014) indicated that balance, limitation, extremity, and relativeness in natural law as well as the awakening and reflection of humans' self-desire and value, from the aspect and viewpoint of humanity, were the major and essential problems and issues faced and emphasized in future environmental education. Gomez (2015) regarded environmental education as proper understanding, attitudes, and accomplishment of humans toward the environment. From certain aspect, it did not have personal choice or freedom. Specifically speaking, it should be the education or accomplishment which everyone should accept; essentially, it presented compulsion and national needness. Kendra and Marianne (2014) mentioned that the content and requirement were not to satisfy individual interests or needs, but to educate and shape the knowledge, cognition, attitudes, and accomplishment of a person, in the world or on the earth, facing the common natural environment or earth of human beings. In other words, Varela-Losada, Vega-Marcote, Perez-Rodríguez, and Alvarez-Lires (2016) pointed out the compulsory character of environmental education, whose contents showed human communality and were different from general scientific education, skill education, or general knowledge education.

Referring to Wee, Mason, Abdilla, and Lupardus (2016), the following dimensions are proposed in this study for environmental education.

(1) Natural system: General concepts of environment, earth, and biosphere.
(2) Earth resources: The distribution, consumption, management, conservation, and pollution of natural resources.
(3) Human-environment: Humans are a part of the environment that regulations should be made to establish environmental value.

Environmental Knowledge

Environmental knowledge is not a primary factor in consumers' environmental behavior (Kopnina, 2014); however, few researchers reveal different opinions (Damerell, Howe, & Milner-Gulland, 2013). For instance, Ramdas and Mohamed (2014) discovered that consumers with richer environmental knowledge were more possible to engage in purchase behaviors beneficial to the environment. Similarly, Joanne and Erminia (2015) indicated that consumers who purchased organic food once a week presented more knowledge about environmental products than those seldom purchased organic food. In the research on consumers' choices of drinks, Aminrad, Zakariya, Hadi, and Sakari (2013) discovered that consumers with high environmental awareness would most possibly purchase drinks with packages beneficial to the environment. For this reason, environmental knowledge was a prerequisite when engaging in beneficial behaviors to the environment. Besides, the lack of environmental awareness would be restricted the beneficial behavior to environment. Perez-Belis, Bovea, and Ibanez-Fores (2015) regarded environmental knowledge as an interdisciplinary subject, which was induced the knowledge from nature, social science, and anthropology; sometimes, it would involve in morality of value and power allocation that it covered broadly, including food, clothing, housing, and transportation of humans. In this case, knowledge related to living and environment could be regarded as environmental knowledge (Hanisch, Rank, & Seeber, 2014).

Referring to Cheng and Wu (2015), the following cognitive dimensions are covered in environmental knowledge in this study.

(1) General knowledge: including the knowledge about the entire environment, e.g. history and ecology of natural environment, social history, and human ecology.
(2) Problem knowledge: containing resources in natural environment and environmental problems caused by resource overuse.
(3) Action knowledge: covering types of environmental actions, solving problems with proper actions, and skills for environmental actions.

Environmental Value

Environmental value refers to "human belief, attitudes, and value to environment to lead and regulate humans' environmental behaviors", and environmental value should present the spirit and content of environmental ethics (Liu, Feng, & Chen, 2013). Individual value orientation of natural environment was the environmental value (Ardoin, Clark, & Kelsey, 2013). Individual value orientation of natural environment was the environmental value, but each person's intrinsic environmental value would affect the attitudes and intrinsic motivation to the environment and form the environmental paradigm (Sapci & Considine, 2014). Simmons and Widmar (2015) divided value into general value and environmental value and advocated that general value would affect environmental value, while environmental value would further influence environmental behaviors. In other words, personal value would affect attitudes, which would further influence the responsible environmental behaviors (Feng, Xindi, & Fushen, 2014). There were many factors in value, e.g. social factors (family, neighbors, peers), exosystem (media, political organizations), and macro system (culture, religion) (Pienaar, Lew, & Wallmo, 2015). For example, some researchers considered that collectivists concerned more about environmental protection than individualists (Kaffashi et al., 2015). Researchers indicated that Judaeo-Christian value was unfavorable to environmental protection (Wee et al., 2016). Kang and Moon (2014) proposed the value-belief-norm (VBN) model to explain the generation of responsible environmental behaviors. Vicente-Molina, Fernández-Sáinz, and Izagirre-Olaizola (2013) regarded environmental value as the special situations in the environment, overall environment, and the belief composition of people, affairs, and objects directly related to the environment. Generally speaking, environmental attitudes could be the behaviors performed by an individual or a group, based on the cognition of the environment, through emotion and motivation (Choi & Fielding, 2013). Wolters (2014) defined environmental value as individual opinions about the entire environmental value and the responsibility and role of humans in the environment to appear the emotional tendency of pro or con, like or dislike environment related affairs.

Referring to Ho (2013), environmental value is composed of following dimensions in this study.

(1) Cognitive component: Understanding and judgment of the environment.
(2) Affective component: Like/dislike emotion to the environment, with emotional tendency.

(3) Behavioral component: Behavioral tendency to the environment.

Correlation Research on Environmental Education and Environmental Knowledge

Gomez (2015) pointed out the ultimate objective of education as to change human behaviors. Most environmental education course plans accept the "knowledge-attitude-behavior" theory, i.e. believing in the increase in environmental knowledge being able to change personal attitudes toward the environment and to further generate responsible environmental behaviors. Environmental education therefore aimed to cultivate and enhance individual or group environmental knowledge (Yucel & Ozkan, 2016). Pandit et al. (2015) regarded environmental education as the educational process to improve environmental problems, mainly teaching people to know the relationship between people and natural environment & artificial environment and cultivate basic concepts to understand the knowledge, attitudes, and skills required for the interaction among culture, creature, and physical environment. Varela-Losada et al. (2016) mentioned that the promotion of environmental education had become the common trend globally. The practice of environmental education could assist people in understanding the ecological role in natural environment and the effect on the environment as well as taking rational preparation or presenting environmental knowledge for sequential management when encountering environmental problems (Hanisch et al., 2014). The following hypothesis is therefore proposed in this study.

H1: Environmental education presents significant correlations with environmental knowledge.

Correlations Research on Environmental Knowledge and Environmental Value

Joanne and Erminia (2015) pointed out the correlations between students' environmental knowledge and environmental value. Research also indicated the positive correlation, i.e. students with higher performance on environmental knowledge presented more active value to environmental problems (Kaffashi et al., 2015). In the research on elementary school students' environmental knowledge and value, Cheng and Wu (2015) indicated that the environmental knowledge had achieved above intermediate degree and revealed positive value on environmental problems. Simmons and Widmar (2015) mentioned that each environmental behavior could not be predicted with a variable a set; apparently, factors in environmental behaviors were complicated. It was necessary to enrich individual basic knowledge of the environment and environmental behaviors, skills, and knowledge to establish individual correct environmental value, cultivate the ability to analyze environmental problems, and think of factors in environmental behaviors so as to effective predict environmental behaviors and solve environmental problems. Accordingly, it is inferred in this study that environmental knowledge cognition would enhance environmental value (Liu et al., 2013). The following hypothesis is then proposed in this study.

H2: Environmental knowledge shows remarkable correlations with environmental value.

Correlation Research on Environmental Education and Environmental Value

Pluess (2015) pointed out the importance to understand students' environmental value in environmental education. According to research on environmental education, Wolters (2014) mentioned the importance to establish students' positive environmental attitudes and value for effectively practicing environmental education. Vicente-Molina et al. (2013) indicated that environmental education also taught people to make decisions when actually facing environmental quality related issues and to develop self-behavioral environmental value. Kang & Moon (2014) revealed the importance of establishing students' positive environmental value in education as it would help solve environmental problems and enhance environmental quality. Siew et al. (2015) stated that environmental education led and educated people how to live in the environment. From the viewpoint of ecology, deep environmental education referred to ecological philosophy, environmental ethics, and responsible environmental value (Feng et al., 2014). Ho (2013) regarded environmental education as the "integrated" education, rather than practicing for certain age groups or certain groups of people; it presented universality, lifelong, and integrity, integrated politics, economics, society, culture, and aesthetics, and was a kind of value and lifestyle (Pienaar et al., 2015). As a result, the following hypothesis is proposed in this study.

H3: Environmental education reveals notable correlations with environmental value.

RESEARCH METHOD

Method and Model

Test for goodness-of-fit in LISREL model is generally measured with overall model fit (i.e. external quality of model) and internal quality of model. In terms of overall model fit, the commonly used goodness-of-fit indicators contain (1) "$\chi 2$ ratio (Chi-Square ratio), standing for the gap between theoretical model and expected value, which

Table 1. Model analysis result

	Evaluation indicator	Judgment standard	result
Overall goodness-of-fit	*p* -value	*p* -value > 0.05	0.000
	χ2/d.f.	< 3	1.671
	GFI	> 0.9	0.976
	AGFI	> 0.9	0.907
	CFI	> 0.9	0.962
	RMR	< 0.05, excellent to be < 0.025	0.015
	RMSEA	0.05~0.08 good excellent to be < 0.05	0.018
	NFI	> 0.9	0.927
	IFI	> 0.9	0.911

is better smaller than 3, (2) goodness of fit index (GFI) and adjusted goodness of fit index (AGFI), which is better close to 1, (3) root mean square residual (RMR), reflecting the square root of "residual variance/covariance mean", which is better smaller than 0.05, and (4) incremental fit index (IFI), which reveals good goodness-of-fit when being higher than 0.9.

Fit of the internal structure model is often used in LISREL, including (1) square multiple correlation (SMC) of individual manifest variable, as R2 of manifest variable and latent variable, which should be higher than 0.5, (2) component reliability (ρ) of latent variable, as the Cronbach's α of the observation indicators of latent variables, which should be higher than 0.6, and (3) average variance extracted of latent variable, which is calculated with the R2 sum of manifest variables of a latent variable divided by the number of manifest variables, revealing the percentage of latent variable being measured with manifest variables, which is better higher than 0.5.

Research Sample and Object

Aiming at students of Central University of Finance and Economics, 360 copies of questionnaire are randomly distributed, and 288 valid copies are retrieved, with the retrieval rate 80%. Central University of Finance and Economics is one of the national "211" key universities to which the Chinese central government has attached top priority for the 21st Century.

Reliability and Validity Test

Validity refers to a measuring scale being able to actually measure the degree which a researcher intends to measure. The common validity contains "content validity", tending to qualitative verification, "criterion validity", using identified external criterion and the correlation coefficient in the test for the evaluation, and "construct validity", used for evaluating the theoretical consistency of a measurement with other observable variables. The questionnaire content in this study is based on past theories and referred to the real situation to design the measuring tool, which could truly express the essence of affairs and complete representativeness, to ensure the questionnaire conforming to content validity. Besides, the ultimate commonality estimate of the Factor Analysis result is applied to test the construct validity of items, and the validity appears in 0.8~0.9, showing good validity test of this questionnaire.

ANALYSIS OF EMPIRICAL RESULT

Model Fit Test

With "maximum likelihood" (ML) estimate, the analysis result achieves the convergence. Overall speaking, the overall model fit indicators pass the test, **Table 1**, reflecting good external quality of model.

Path Relationship Test

In regard to the test of internal quality of model, SMC of manifest variables is higher than 0.5 (**Table 2**, **3**), revealing good measuring indicators of latent variables. Furthermore, latent variables of environmental knowledge, environmental education, and environmental value show the component reliability higher than 0.6, and the average variance extracted of dimensions is higher than 0.5 (**Table 4**), apparently conforming to the test requirement for fit of the internal structure model.

Table 2. SMC of variable to dimension

environmental knowledge		
general knowledge	problem knowledge	action knowledge
0.72	0.76	0.83

Table 3. SMC of variable to dimension

environmental education			environmental value		
natural system	earth resources	human-environment	cognitive component	affective component	behavioral component
0.75	0.80	0.86	0.77	0.79	0.82

Table 4. Component reliability and average variance extracted of variable

Item	environmental knowledge	environmental education	environmental value
component reliability	0.827	0.856	0.891
average variance extracted	0.83	0.85	0.89

Table 5. Linear Structural Relations Model analysis

Evaluation item	parameter/evaluation standard	result	t
internal fit	environmental education→environmental knowledge	0.874	27.39**
	environmental knowledge→environmental value	0.866	16.73**
	environmental education→environmental value	0.835	21.46**

Table 6. Hypothesis test

Research hypothesis	Correlations	Empirical result	P	result
H1	+	0.874	0.00	supported
H2	+	0.866	0.00	supported
H3	+	0.835	0.00	supported

From the model analysis result, **Table 5**, environmental education presents positive and significant correlations with environmental knowledge (0.874), environmental education reveals positive and remarkable correlations with environmental value (0.835), and environmental knowledge appears positive and notable correlations with environmental value (0.866) that H1, H2, and H3 are supported. The research hypothesis test is shown in **Table 6**.

CONCLUSION

The research results reveal that environmental education is the fundamental part, allowing students knowing and understanding objective and tangible environmental facts and phenomena, realizing how to deal with, solve, or prevent from environmental damage or worsening, understanding the essence of tangible natural environment, the unchanged abstract rules behind natural environment, and the status and role in natural environment, as well as cultivating environmental knowledge and environmental value to seek for getting along with natural environment permanently. The orientation and shaping of environmental value is the major objective, the final objective and pursuit of environmental education, as well as people getting along with natural environment without damaging the nature. Students spend about one-third of a day at schools that campuses naturally become the largest learning space for students. Under limited educational resources, administrators or teachers being able to well plan campus environment to match with campus environment for education could benefit students' physical and mental development as well as acquire environmental knowledge and intangible environmental value in the environmental education to develop the maximal learning effect.

SUGGESTION

Aiming at the important research results and findings, following practical suggestions are proposed in this study.

1. Environmental education teacher training institutions should hold trainings and studies related to course planning, design, and integration for in-service teachers' environmental education study, cultivating in-service teachers' professional ability of environmental education research and development, and enhancing in-service teachers' environmental education integration concepts and abilities.

2. When promoting environmental education, teachers should be induced the potential, affirm the efforts, and enkindled the insistence and passion for environmental education. Teachers would not give up the mission because of not being materially rewarded. Schools should create the affirmative and supportive climate and timely provide spiritual and material incentives so that teachers would devote themselves due to spiritual encouragement and support. Moreover, schools should provide environmental education trainings and even announce sharing opportunities for environmental education teachers present self-confidence on the stage and be touched with the growth.
3. In environmental education teaching process, students should be encouraged to present opinions aiming at various environmental problems and guided deeper discussions aiming at different types of environmental knowledge and value so that students could re-clarify and construct the environmental value through criticism and comparison. Extending and responding to environmental problems discussed in classes could gave the discussion in classes be deeper and more efficient. Students could respond to environmental problems in daily life and announce personal ideas by writing diaries. Teachers could effectively understand students' environmental knowledge and value with value sheets and diaries and give guidance and affirmation to students' environmental knowledge and value.

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Effects of Instructional Multimedia Integrated Situational Approach on Students' Learning Achievement

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ABSTRACT
The instructional multimedia teaching effectiveness significantly enhances teaching quality that it does not simply break through the restriction on time and space, but could also receive immediate learning achievement, assist in traditional instruction, and provide learners with diverse learning and innovation ability. The advantage of instructional multimedia becomes the mainstream of education. With nonequivalent pretest posttest control group design, 198 students of Chongqing University of Education is proceeded the 15-week (3 hours per week for total 45 hours) teaching experiment. The research results reveal remarkable effects of 1.instructional multimedia on learning effect, 2.instructional multimedia on learning gain, 3.Situational Approach on learning effect, 4.Situational Approach on learning gain, 5.instructional multimedia integrated Situational Approach on the promotion of learning effect, and 6.instructional multimedia integrated Situational Approach on the enhancement of learning gain. According to the results, suggestions are proposed, expecting to provide students with the diverse and practical learning model to assist students in cultivating adequate basic abilities and allow students actively participating in discussions and solving problems in the instructional multimedia integrated Situational Approach teaching situation so as to enhance the learning motivation and promote the learning achievement.

Keywords: instructional multimedia, situational approach, learning achievement

INTRODUCTION

The popularity and diverse development of computer technology relies on the function of computer multimedia (John, Nwosu, & Akorede, 2018). Accordingly, teaching and multimedia digital also appear critical influence. Current "instructional multimedia" becomes an alternative teaching tool beyond traditional learning. In terms of education, the teaching effectiveness significantly enhances teaching quality to break through the restriction on time and space and receive immediate learning achievement to assist in traditional instruction and provide learners with diverse learning and innovation ability. Besides, instructional multimedia is an important part of education, and the advantage of instructional multimedia would become the mainstream of education (Abbasi, Moeini, Shahriari, Ebrahimi & Khoozani, 2018).

The Internet learning environment is not restricted on time and location and could provide various diversified materials and course contents for learners constructing knowledge through communication, discussion, and interaction & exchange. The application of new technologies, like computer multimedia and the Internet, and new knowledge therefore could have learners reach learning achievement to manifest teaching quality.

A lot of children with low learning degree present laggard learning, could not fluently express the ideas in daily life, and even affect other learning and comprehension in life. With detailed analyses, inadequate cultural stimuli in the growth background and little meaningful communication and expressive interaction with family members and peers have school learning disconnect with the life. Such disconnected learning background and life experience have students not smoothly express the ideas. In this case, it is an urgent problem to enhance pupils' learning

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Contribution of this paper to the literature

- To promote teachers pursuing professional growth, teachers should be encouraged to engage in teaching research, find out problems and propose strategies for improvement, review and revise final evaluation, and constantly improve teaching methods.
- Either pictures or films could attract students' attention, but film watching is the first choice of most students. For this reason, local students, campus life, and hometown environment are the first choices as the situations in the application of instructional multimedia integrated Situational Approach to induce consonance.
- With the advance of technology, the popularity of networks, and the promotion of information software and hardware, a lot of products are looked for the possibility of being applied to education, and lots of development and research results would benefit children in the next generation.

achievement in class. Traditional education with unrealistic materials or teaching activities not arousing students' learning motivation is regarded as dangerous by many students. To improve traditionally cramming and didactic education and avoid disconnection between teaching contents and life experience, learner-centered education is proposed and Situational Approach emerges. Situational Approach stresses on "learning by doing" and "reflecting through doing". In the teaching context constructed by teachers, students have the opportunities to actively participate in learning and interaction that having students construct meaningful knowledge is the key point in situated teaching. Aiming at the effect of instructional multimedia integrated Situational Approach on students' learning achievement, a diverse and practical learning model is provided for assisting students in cultivating adequate basic abilities and allows students actively participating in discussion and solving problems in the instructional multimedia integrated Situational Approach teaching situation to enhance the learning motivation and promote the learning achievement.

LITERATURE REVIEW

Instructional Multimedia

It refers to the teaching methods being presented with computer controlled programs for learners directly contacting computers as the learning activity (Hong, 2016). Various media experience several times of evolution to appear the new term "computer multimedia", which refers to having computers integrate and organize various media elements, e.g. texts, images, films, animation, and music, and present the functions of storage, edition, and control (Lin, Huang, & Chuang, 2015). It is an education concept and the teaching process presenting materials and controling individualized learning environment directly with the application of computer communication (Liu & Lee, 2013). The characteristic of integrating images and audio-video of interactive instructional multimedia added communication and media technologies could generate diverse and open learning environment to further enhance the role in education reform (Adıguzel & Orhan, 2017). Computers show the role of instructor to solve statistical analysis, word processing, data management, and program design as well as assist students in learning lessons for the individualized, mastery learning, or programmed instruction in remedial teaching (Ng, 2016). Instructional multimedia provides individualized instruction, aiming at students' individual abilities, to achieve the educational goal of teaching students accordance with the aptitude and remedy students' inadequate learning, rather than replacing formal teaching methods. In this case, instructional multimedia utilizes the visual situated space designed by new systems or new communication methods developed with electronic media digitalization for providing learners with better digital learning platforms (Deshmukh, Kaushik, & Tayade, 2013). Sun et al. (2015) proposed that teachers specifically applied the functions of computer multimedia, such as films, images, presentation, and network, and broke away teachers' didactic teaching and knowledge delivery through texts and simple images in textbooks in the past. Järvelä et al. (2016) used instructional multimedia for learners' easy comprehension and effective achievement of teaching goals. Instructional multimedia has become the basic competence of teachers and would be the essential teaching mainstream in the future.

Situational Approach

Lee, Lee, Seo, and Choi (2015) regarded the idea of Situational Approach as placing learning in real or simulated situations to have students, through the interaction with the situations, more efficiently apply learned knowledge to real life. The integration into the situations facilitated students' positive and active learning, knowledge construction, and independent thinking in real life, while teachers changed the role from knowledge authorities into learners' partners. Mahmoodi, Kalantari, and Ghaslani (2014) mentioned that, in Situational Approach oriented learning, teachers were auxiliaries to set up scaffolds according to student needs, support and encourage students positively participating in activities and learning problem solving, remove scaffolds step by step according to students' enhancement of individual abilities, and promptly transfer learning responsibilities to learners. Cigdem (2015) stated that Situational Approach stressed on learning in real situations to construct meaningful knowledge; rich learning environments should be designed for teaching to lead learners evaluating and developing knowledge from various aspects. For the application to instruction, Situational Approach focused on environments for experiencing and learning as well as learning by doing and doing by learning in real situations to induce the learning motivation, and constantly establishing the meanings of knowledge through the interaction with situations. Learning environment conforming to above principles was regarded as situated learning environment (Rani, Nayak, & Vyas, 2015), which emphasized the interaction between learners and situations that knowledge should be constructed in real situations and could not be separated from contexts (Hong & Ditzler, 2013). The knowledge construction essentially allowed learners constructing knowledge and skills through observation, imitation, and actual participation in activities and situations in the activity, culture, and social context environment to really grasp knowledge (Stantchev, Prieto-González, & Tamm, 2015). The knowledge transfer and the induction of learners' learning interests and learning motivation (Lin & Tsai, 2016) required the integration of knowledge in situation cognition and learning situations. As a result, having learners present learning ideas and learning behaviors in proper situated environments could really learn knowledge.

Learning Achievement

Lin, Wen, Jou, and Wu (2014) regarded "learning" as individuals generating persistent changes of behaviors or behavior potential through practice or experience; and, learning achievement referred to learners' growth, effect, or achievement to goals preset by instructors after a period time of learning. DaRochaSeixas, Gomes, and DeMeloFilho (2016) pointed out learning achievement as the indicator to measure learners' learning outcome as well as a major item to evaluate teaching quality. Menon (2016) considered that learning achievement was an indicator to evaluate students' absorption of course contents, and teachers' teaching effectiveness could be judged according to students' test performance. Huang, Chen, Hwang, and Huang (2013) referred learning achievement to the evaluation or test of learners after completing learning activities to understand the achievement to the learned contents. Shadiev, Hwang, Huang, and Liu (2015) regarded learning achievement as the learning outcome and performance during the participation in activities. Hu and Driscoll (2013) proposed learning achievement as learners' performance on the participation in learning activities. Piccoli, Ahmad, and Lves (2001) pointed out learning achievement as learners' changes in cognition, affection, and skills after the teaching. Liaw and Huang (2013) referred learning achievement to students' behavioral changes before and after receiving education; and, the changes of deducting "starting behavior" before the education from "end behavior" after the education was the "direct" learning achievement of students. Relatively, "indirect" learning achievement referred to the effect being presented a period of time after students receiving education.

According to Han and Won (2016), learning achievement includes two dimensions in this study.

(1) Learning effect, containing test performance, time for schedule completion, and term performance

(2) Learning gain, covering learning satisfaction, achievement, and preference.

METHOD AND SAMPLE

Research Hypothesis

Wang et al. (2014) indicated that computers' rapid and accurate data acquisition could help learners realize abstract or inferred theories; applying computer simulation tools to learning was more flexible than traditional teaching activities, and the application of instructional multimedia could effectively enhance students' learning achievement (Adıguzel & Orhan, 2017). Shorfuzzaman et al. (2014) mentioned that instructional multimedia combining software, hardware, and peripherals mainly presented on screens to enhance visual and hearing stimulation, showed discourse or interactivity functions to activate teaching and provide learning for learners. Hong (2016) described that teachers, when engaging in teaching, allowed learners proceeding learning with personal abilities and time, recorded the learning processes and schedule, and understood learners' learning conditions for the teaching improvement to largely improve students' learning achievement. Accordingly, the following hypotheses are proposed in this study.

H1: Instructional multimedia shows significant effects on learning effect.

H2: Instructional multimedia reveals remarkable effects on learning gain

In the research on how children learn vocabulary, Zhua, Aub, and Yatesb (2016) indicated that learning vocabulary through daily communication was faster and more efficient than learning from the definition and examples in dictionaries. Integrating learning into life experience had learning be more meaningful with better

Table 1. Difference analysis of instructional multimedia

variable		F	P	Scheffe post-hoc
instructional multimedia	learning effect	9.762	0.000**	instructional multimedia>traditional instruction
	learning gain	10.133	0.000**	instructional multimedia>traditional instruction

* stands for p<0.05 and ** for p<0.01

learning achievement. Shyu and Jiang (2016) pointed out the mutual effect between real life situations and knowledge learning; students' learning required the support of familiar real contexts. After students comprehended the knowledge concept in contexts, knowledge was further applied to solve problems in life. Such a mutual effect relationship was a motive promotion model. Students' knowledge schema was pushed from simple and loose structure to complicated and exquisite to effectively enhance learning achievement. In the research on campus English environment use and learning satisfaction, Menon (2016) indicated that the establishment of campus English environment could actually assist in the promotion of English education, and students in schools with situated English learning environment showed higher use satisfaction and learning achievement than those in schools without the environment. With experimental research, Wang et al. (2014) integrated role play into Situational Approach for junior high school students' English teaching and discuss the learning achievement. The students were provided real English use situations, practiced English through role play, and creatively used English knowledge for facilitating learning transfer and enhancing learning motivation. The research results revealed notable progress of learning achievement in speaking and listening as well as enhancement of learning needs and attitudes. The following hypotheses are further proposed in this study.

H3: Situational Approach presents notable effects on learning effect.

H4: Situational Approach appears significant effects on learning gain.

Xu, Perfetti, and Chang (2014) regarded computer multimedia as an effective tool to fulfill situated teaching, as it presented the design principle of the instructional theory. The linked story developed with well-designed software could induce learners' interests so that learners could reflect the learning process in the operation process and contact more accidental possibilities in the cycled execution to efficiently enhance learning achievement (Rani et al., 2015). Siadatya, Gaševićb, and Hatala (2016) mentioned that instructional multimedia integrated Situational Approach could achieve the goals of cognition, affection, skills, and life education as well as enhance learners' learning intention. Situated learning for instructional multimedia courses should be integrated into relevant tasks to integrate knowledge into learning situations for learners interacting and actively participating in learning activities from simple observation, imitation, and learning to knowledge and skills so as to achieve the interaction between simulated situational activities and learning situations and promote learning achievement (Lin & Tsai, 2016). Sun et al. (2015) concluded that, in computer multimedia learning contents, learners should present learning ideas and behavioral goals, integrate and organize learning theories, and take the prior knowledge and individual difference into account to create quality learning environment and enhance learning intention and achievement. Accordingly, the following hypotheses are proposed in this study.

H5: Instructional multimedia integrated Situational Approach shows remarkable effects on learning effect.

H6: Instructional multimedia integrated Situational Approach reveals notable effects on learning gain.

Research Object and Research Design

To effectively achieve the research objective and test the research hypotheses, nonequivalent pretest posttest control group design is applied to the experiment in this study. Total 198 students of Chongqing University of Education is proceeded Situational Approach integrated instructional multimedia 2╳2 experiment. The experiment is grouped Situational Approach (Situational Approach, traditional instruction) ╳instructional multimedia (instructional multimedia, traditional instruction) for 15-week (3 hours per week for total 45 hours) teaching research.

ANALYSIS AND RESULT

Difference Analysis of Instructional Multimedia to Learning Achievement

Analysis of Variance is applied to discuss the difference of instructional multimedia in learning effect and learning gain. From **Table 1**, instructional multimedia and traditional instruction appear significant differences in learning effect, instructional multimedia showing higher learning effect than traditional instruction, that H1 is supported. Furthermore, instructional multimedia and traditional instruction reveal significant differences in learning gain, instructional multimedia presenting higher learning gain than traditional instruction, that H2 is supported.

Table 2. Difference analysis of Situational Approach

variable		F	P	Scheffe post-hoc
Situational Approach	learning effect	12.738	0.000**	Situational Approach>traditional instruction
	learning gain	13.662	0.000**	Situational Approach>traditional instruction

* stands for p<0.05 and ** for p<0.01

Table 3. Difference analysis of instructional multimedia integrated Situational Approach in learning achievement

variable	learning effect			learning gain		
	F	P	Scheffe post-hoc	F	P	Scheffe post-hoc
instructional multimedia	9.762	0.000**	instructional multimedia>traditional instruction	10.133	0.000**	instructional multimedia>traditional instruction
Situational Approach	12.738	0.000**	Situational Approach>traditional instruction	13.662	0.000**	Situational Approach>traditional instruction
instructional multimedia*Situational Approach	33.527	0.000**	11>12>21>22	36.435	0.000**	11>21>12>22

* stands for p<0.05 and ** for p<0.01

Difference Analysis of Situational Approach to Learning Achievement

According to Analysis of Variance, the difference of Situational Approach in learning effect and learning gain is discussed. From **Table 2**, Situational Approach and traditional instruction show remarkable differences in learning effect, Situational Approach revealing higher learning effect than traditional instruction, that H3 is supported. Moreover, Situational Approach and traditional instruction appear notable differences in learning gain, Situational Approach showing higher learning gain than traditional instruction, than H4 is supported.

Effects of Instructional Multimedia Integrated Situational Approach

Analysis of Variance is utilized for discussing the difference of instructional multimedia integrated Situational Approach in learning achievement; besides, two-way Analysis of Variance is applied to discuss the interaction of instructional multimedia and Situational Approach to verify the enhancement of Situational Approach. From **Table 3**, instructional multimedia integrated Situational Approach presents the highest learning effect and learning gain that H5 and H6 are supported.

CONCLUSION

This study discusses the effect of instructional multimedia integrated Situational Approach on students' learning achievement. The results reveal that students, with instructional multimedia integrated Situational Approach, significantly enhance the learning achievement. Integrating instructional multimedia into situated teaching could activate school teaching to be more practical and create learning environments suitable for students. Besides, students spend a lot of time on campus that daily life environments are the best practice situations; both teachers and students are encouraged to largely use situated teaching. Besides, teaching with instructional multimedia integrated Situational Approach could help students' learning achievement that teachers could utilize instructional multimedia integrated Situational Approach for assisting students in comprehending abstract knowledge and linking with life experience through diverse materials and learning activities. Once students are accustomed to a single method, which would become standard learning activity, they would gradually lose the attraction. Instructional multimedia with pictures, audio-video pictures, or network resources could inspire learners' learning motive and reduce learning obstacles.

RECOMMENDATIONS

According to the research conclusion, the following suggestions are proposed in this study.

1. The rapid advance of information technology has changed learning styles. To satisfy teaching needs, educators should keep up with the time and well apply the advantages of computer multimedia to teaching. It is not to pursue novelty, but to consider the course needs and timely apply instructional multimedia to teaching activities. Learners, instructors, as well as teaching strategies and materials are the key factors in

learning achievement. To promote teachers pursuing professional growth, teachers should be encouraged to engage in teaching research, find out problems and propose strategies for improvement, review and revise final evaluation, and constantly improve teaching methods.

2. Either pictures or films could attract students' attention, but film watching is the first choice of most students. For this reason, local students, campus life, and hometown environment are the first choices as the situations in the application of instructional multimedia integrated Situational Approach to induce consonance. Materials through instructional multimedia integrated Situational Approach could attract attention and increase learning interests; especially, materials related to student life could better induce experience link.
3. With the advance of technology, the popularity of networks, and the promotion of information software and hardware, a lot of products are looked for the possibility of being applied to education, and lots of development and research results would benefit children in the next generation. Urban-rural gap should be avoided in order to maintain education quality. Educational units therefore are suggested to draw complete and permanent information education plans, including the establishment or augmentation of wireless network on campus and basic establishment of personal computers and projectors.

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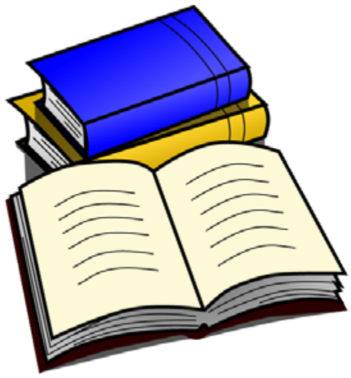

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Examining the Differences of Hong Kong and Taiwan Students' Performance on the Number Sense Three-tier Test

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ABSTRACT

Assessing elementary students' performance on number sense provides early predictors and support for interventions in teaching and learning number sense before children fall seriously behind in school. There is no study that concerns the differences between Hong Kong and Taiwan students' performance on the number sense three-tier test. The purposes of this study were to examine the differences of Hong Kong and Taiwan students' performance on the number sense three-tier test and the possible misconceptions. A total of 125 fifth graders, 942 sixth graders from Hong Kong, and 819 fifth graders from Taiwan participated in this study. Results show that there are significant differences on the performance of first two-tier test and confidence between the fifth graders of HK and Taiwan, sixth graders of HK and fifth graders of Taiwan, respectively. Strong misconceptions and key differences among the HK fifth graders, HK sixth graders, and Taiwan fifth graders were found and discussed.

Keywords: Hong Kong, number sense, Taiwan, three-tier test

INTRODUCTION

Many studies highlighted that number sense (NS) should play an important role in school mathematics teaching and learning internationally (Berch, 2005; Dunphy, 2007; Griffin, 2004; Jordan, Glutting, Ramineni, & Watkin, 2010; Lin, Yang, & Li, 2016; McIntosh, Reys, & Reys, 1992; National Council of Teachers of Mathematics [NCTM], 2000; Sowder, 1992; Yang & Li, 2013). In addition, number sense also plays a key role in our daily life (Dehaene, 1997; Yang, & Wu, 2010). Therefore, helping children develop number sense has been emphasized internationally by many researchers and reports (Australian Education Council, 1991; Berch, 2005; Dunphy, 2007; Jordan, Glutting, & Ramineni, 2010; Jordan, Kaplan, Locuniak, & Ramineni, 2007; McIntosh, Reys, Reys, Bana, & Farrel, 1997; Sood & Jitendra, 2007; Verschaffel, Greer & De Corte, 2007; Yang, & Li, 2013; Yang, & Wu, 2010). Earlier studies argued that lack of number sense often leads to learning disabilities in mathematics to a certain degree (Dyson, Jordan, & Glutting, 2013; Jordan et al., 2007, 2010). If students are able to exercise number sense flexibly, it will help them keep learning effects longer (Jordan et al., 2010; Yang, Li, & Lin, 2008). This shows the importance of number sense.

Hong Kong and Taiwan students performed very well on international mathematics assessments, such as The Trends in International Mathematics and Science Study (TIMSS) 2015 (Mullis, Martin, Foy, & Hooper, 2016) and The Programme for International Student Assessment (PISA) 2015 (Organization for Economic Co-operation & Development [OECD], 2016). However, these international mathematics assessments didn't focus on students' reasons, misconceptions, and confidence on number sense, though the studies examined students' performance on number domain. Assessing number sense [including students' reasons, misconceptions, and confidence] is crucial to the teacher to see students' understanding of numbers and its operation (Akkaya, 2016; Şengül & Gülbağcı, 2014; Yang, & Li, 2013; Yang, & Wu, 2010). The screening test of students' performance on number sense can be used to provide early predictors and support for interventions in teaching and learning number sense before children fall seriously behind in school (Gersten, Jordan, & Flojo, 2005; Jordan et al., 2010). In addition, previous studies revealed that secondary school students experience difficulties on number sense (Şengül, & Gülbağcı, 2012, 2014). By assessing elementary students' performance and misconceptions on number sense, this study provides the results

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Contribution of this paper to the literature

- Hong Kong 5th and 6th grade and Taiwan 5th grade students do not perform well on number sense as compared to their performance on international mathematics assessments (e.g. PISA and TIMSS).
- HK 5th and 6th grade students are not only significantly performed better on NS both-tiers test than Taiwan 5th grade students, but also are more confident in answering NS two-tiers test than Taiwan 5th grade students.
- Key differences on the number sense performance and misconceptions between HK and Taiwan students exist.

of students' performance and possible misconceptions on number sense. The Authors believes that it would be beneficial for the teacher to address a preliminary strategy and teaching development in elementary grades in order to improve students' ability on number sense when they look forward to attending secondary schools. These notions motivated the authors to assess the elementary students' performance on number sense.

The results of students' performance on number sense are also crucial and challenging to the curriculum designers in a country, in which the results could be a reflection and consideration for developing and improving the curriculum standards. If we look at the mathematics curricula in Hong Kong and Taiwan, the curricula have highlighted the needs of instruction for developing students' number sense: (1) the reforms in the school mathematics curriculum in Hong Kong have emphasized the needs for teachers to provide instructions that lead to conceptual understanding for students to develop number sense and teacher should carry out activities to foster number sense (Hong Kong Curriculum Development Council and the Hong Kong Examinations and Assessment Authority, 2014) and (2) Taiwan's major mathematics curriculum reforms have highlighted that mathematics instruction should help children in developing number sense skills (Ministry of Education in Taiwan, 2017). Moreover, The NS study at Hong Kong is the first systematic study in number sense of students in Hong Kong. However, their performance is not as good as what has been seen from the other international assessment tests in mathematics. It would be of interest to compare their results with Taiwan, a place where the research of NS has been done systematically (Taiwan experienced the same as Hong Kong that students were not performing well in the NS test despite they performed better in other international assessment tests). Thus, we could know better about the NS of students in Asia with similar backgrounds and educational systems.

In this study, the Authors developed a number sense three-tier test [NSTTT] to examine the differences of Hong Kong and Taiwan students' performance on number sense. The NSTTT is a test that examines students' knowledge of number sense (contents), reasons, and confidence level. The number sense three-tier test [NSTTT] includes a content-tier (first-tier) which examines content knowledge of number sense; a reason-tier (second-tier) which examines a reason selected for the first-tier response; and the confidence-tier (third-tier) which assesses how confident the students are in their answers to the first two-tiers (Yang, & Li, 2017). The number sense three-tier test (NSTTT) used in this study was designed by the authors. The NSTTT includes five number sense components and each has 8 questions. The third-tier in the NSTTT used the five-point Likert scale, including very confident, confident, neutral, unconfident, very unconfident, to examine students' confidence after they responded to the first two-tier of the questions. It is used to rate the students' confidence level regarding their answers to the first two-tier (Yang, & Li, 2017).

Ultimately, the Authors believes that assessing students' performance and the misconceptions would provide particularly noteworthy contributions in developing better curricula in the two countries since the fact showed that the reforms of both countries' curricula have emphasized and highlighted the development of number sense. The results of this study clarify the situation of students' performance on number sense in the two countries. Furthermore, no study examines the differences on number sense between Hong Kong and Taiwanese students. This also encouraged the authors to conduct the current study. According to the aforementioned issues, this study sought to address these research questions:

1. Are there any significant differences on the NSTTT between Hong Kong and Taiwan students?
2. Are there any significant differences on the methods used by Hong Kong and Taiwan students?
3. What are the key differences and students' misconceptions on the NSTTT between Hong Kong and Taiwan students?

LITERATURE REVIEW

Number Sense Components

Number sense refers to a person's general understanding of numbers and operations, and the ability to handle numerical problems in the daily life situations via the use of flexible and efficient strategies (e.g. mental computation or proficient estimation) (Markovits & Sowder, 1994; McIntosh et al., 1992; Reys & Yang, 1998; Yang, & Li, 2013). Number sense components have been broadly discussed by many studies and documents over the past two decades (Berch, 2005; Chen, Li, & Yang, 2015; Gersten, Jordan, & Flojo, 2005; Jordan et al., 2010; Markovits, & Sowder, 1994; McIntosh et al., 1992; NCTM, 2000; Reys, & Yang, 1998; Verschaffel et al., 2007; Yang, & Li, 2008). Based on the above references, this study defined that number sense components should include five pivotal components. They are: C1: Being able to understand the basic meaning of numbers and operations; C2: Being able to recognize the number size; C3: Being able to use multiple representations of numbers and operations; C4: Being able to recognize the relative effect of operations on numbers; and C5: Being able to judge the reasonableness of a computational result via different strategies.

Number Sense Three-tier Test Related Studies

Due to the importance of number sense, several studies have developed and applied the number sense web-based two-tier test to assess children's number sense performance (e.g., Chen, Li, & Yang, 2015; Yang, & Li, 2008). The first-tier test in the two-tier test assesses content knowledge of number sense, and the second-tier test examines children's reasons for their related choice made in the first-tier test (Chen, Li, & Yang, 2015; Yang, & Li, 2008). However, this two-tier test does not allow students to rate the strength of their confidence as to why they selected their answers to the first two-tiers (Caleon & Subramaniam, 2010; Clement, Brown, & Zietsman, 1989). Based on the three-tier tests used in science education (Caleon, & Subramaniam, 2010; Cetin-Dindar, & Geban, 2011; Pesman, & Eryilmaz, 2010), Yang and Li (2017) designed and applied the number sense three-tier test to measure students' number sense performance, misconceptions, and the level of confidence.

The findings of earlier studies in Science (e.g., Caleon, & Subramaniam, 2010; Cetin-Dindar, & Geban, 2011; Pesman, & Eryilmaz, 2010) showed that the three-tier test can be a more reliable and valid instrument than the two-tier tests to identify students' conceptual understanding and the strength of students' confidence level to answer questions can be used to confirm students' misconceptions. The findings of studies by Lin, Yang, and Li (2016) and Yang and Li (2017) showed that many sample students performed poorly on number sense, but with extremely high confidence indicating that many students have significant misconceptions and some students may lack number sense. This study also confirmed that a third-tier (with confidence rating) number sense test can be used to mitigate the weakness of a two-tier test.

Number Sense Related Studies in Hong Kong and Taiwan

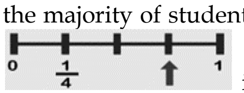
The authors must point out that there are only few studies on number sense involving Hong Kong and Taiwan. Such studies have focused on students' performance on number sense. There is only one published article by Aunio et al. (2004) concerning number sense in Hong Kong. However, number sense has recently received a growing attention from researchers in Taiwan, though there are only few published research works in the literature. Aunio et al. (2004) investigated young children's number sense in Finland, Hong Kong, and Singapore. Their results showed a significant age-related gain in counting and relational skills of number sense, and no gender differences were found. They reported that children in Hong Kong and Singapore outperformed the children in Finland on relational and counting skill tasks, and the students in Singapore performed better than in Hong Kong. On the other hand, the existing studies in the literature have consistently shown that primary school children in Taiwan performed poorly on number sense-related questions in the last two decades (see, e.g., Reys, & Yang, 1998; Yang, & Li, 2008, 2017; Yang, & Wu, 2010).

In the preliminary investigation, Reys and Yang (1998) not only investigated the relationship between number sense and written computation test performance for the sixth and eighth graders in Taiwan but also interviewed the students to examine their responses to number sense-related questions. They found that those students were much more successful on written computation than on number sense. They pointed out that children who are successful in written computation do not necessarily have a well-developed number sense. In addition, Yang (2003) investigated the number sense performance of the fifth graders in Taiwan and found that the students' performance was low with a mean percentage of correct answer about 32%. Further, Yang and Li (2008) studied the number sense performance of the third-grade students and reported that the students did not perform well on the number sense test with the mean percentage of the correct answer around 34%.

Afterward, Yang and Wu (2010) conducted a teaching experiment for the third-grade students on number sense through paper-and-pencil tests and interviews. The authors compared the performance of students who received integration of number sense activities in instruction with students who received instruction using regular mathematics textbooks. They found that the students in the experimental class [exposed to number sense-teaching materials (pedagogy)] performed significantly better than in the control class (received regular textbooks instruction) in solving number sense problems and using number sense-based methods to solve the problems. Nevertheless, Yang and Li (2008) argued that the reason of those primary students having low performance on number sense could be related to the contents of mathematics textbooks that do not present number sense-related activities, which influence teachers to not teach number sense in mathematics classes.

Related Studies on Students' Misconceptions

Reported in the existing literature, the majority of students found considerable misconceptions in solving mathematics problem involving computation and representation, particularly related to fraction, decimal, and multiplication and division. Regarding the computation, majority students performed several misconceptions in fractions (see, e.g., Alghazo, & Alghazo, 2017; Ashlock, 2006; Education Development Center in USA, 2015; Trivena, Ningsih, & Jupri, 2017), such as adding both numerators and denominators (e.g., 1/3 + 2/5 =3/8), keeping the same numerator and adding the denominators (e.g., 2/3 + 2/5 = 2/8), writing the least denominator and adding the numerators (e.g., 2/3 + 3/6 = 5/3), students often fail to convert fractions to a common, equivalent denominator before adding or subtracting them, and instead just use the larger of the two denominators in the answer (e.g., 4/3 + 4/6 = 8/6), leaving the denominator unchanged in fraction addition and multiplication problems (e.g., 2/5 × 1/5 = 2/5).

Regarding the representation, Dhlamini and Kibirige (2014) found that students don't use the representation properly to represent a fraction or decimal (e.g., the shaded part in  is 1/3). In addition, Durkin and Rittle-Johnson (2015) also found that the majority of students are not able to place a number on a number line (e.g., the arrow pointing in the picture 

is 0.6). Griffin (2016) also observed that students perform misconceptions on reading and presenting the value in decimal (e.g., 1/2 + 0.5 = 1.5/2). Moreover, regarding the computation, Joseph (2014) argued that the order of operations regarding mnemonic device PEMDAS (Parentheses, Exponents, Multiplication, Division, Addition and Subtraction) influenced heavily on students' misconceptions in solving multiplication and division. Therefore, students tended to solve the multiplication before division (e.g., 125÷2×3 = 125÷(2×3)). In addition, America's Choice (2012) documented that students may know the commutative property of multiplication but fails to apply it to simplify the work of multiplication (e.g., 100÷3×10＝100÷10×3).

METHOD

Samples

125 fifth graders (about 10-11 years old) and 942 sixth graders (about 11-12 years old) from Hong Kong and 819 fifth graders (about 10-11 years old) from Taiwan willingly participated in the number sense three-tier test. The sample included 39 classes from sixth graders and 5 classes from fifth graders of Hong Kong and 31 classes from fifth graders of Taiwan. The elementary educational system (i.e., from grade 1 to grade 6) in Hong Kong and Taiwan is similar. The test was conducted in the two locations by using Chinese version. All of the students in the test are fluent in Chinese. The grade 5 and grade 6 students in Hong Kong were from fourteen elementary schools located in different districts with varied socio-economic status. The grade 5 students in Taiwan were from twelve elementary schools located in different areas (i.e., north, middle, and south area) with varied socio-economic status. The difference of students' socio-economic status in Taiwan is more obvious as compared to students from Hong Kong, because Hong Kong is a big city and Taiwan contains a wider range of areas.

Instrument

The NSTTT contains the two-tier test and the third-tier (confidence-tier), which assesses how confident the students are, in their answers to the first two-tiers (Yang & Li, 2017). The two-tier test consists of a content-tier which examines content knowledge of number sense (first-tier); and a reason-tier which examines a reason selected for the first-tier response. The three-tier test consists of the two-tier test and the third-tier (confidence-tier), which assesses how confident the students are, in their answers to the first two-tiers (Yang & Li, 2017). The number sense three-tier test (NSTTT) used in this study was designed by the authors (Yang & Li, 2017). The third-tier used the five-point Likert scale, including Very Confident, Confident, Neutral, Unconfident, Very Unconfident, to examine

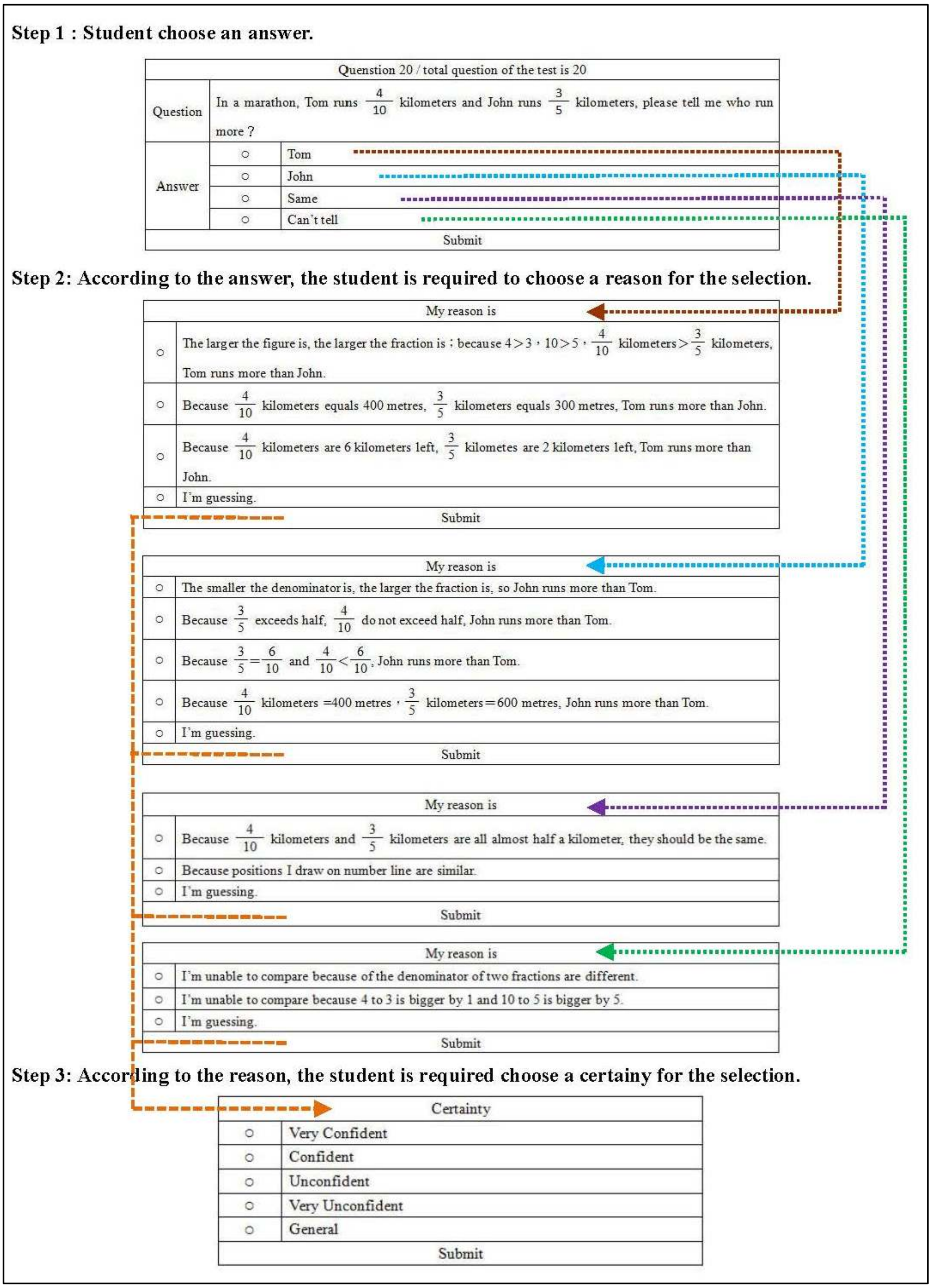


Figure 1. An Example of the NSTTT

students' confidence after they responded to the first two-tier of the questions. It is used to rate how confident students are about their answers to the first two-tier (Yang, & Li, 2017). The NSTTT includes five number sense components as described in the literature reviews and each has 8 items. So, there are 40 items totally. An Example of the NSTTT is described in **Figure 1**.

Table 1. The scoring rule of the three-tier test

		Number Sense Test				
1st stage	Answer options	Correct answer				Wrong answer
		4 points				0
2nd stage	Reason options	**NS-based**	**Rule-Based**	**Misconception**	**Guessing**	
		4	2	1	0	0
	Score	8	6	5	4	0
3rd stage		(CRI in a NS test)				
	CRI	Very confident	Confident	Neutral	Unconfident	Very Unconfident
	Score	5	4	3	2	1

Treatment of Data

Based on the earlier studies of three-tier test by the authors (Caleon, & Subramaniam, 2010; Cetin-Dindar, & Geban, 2011; Pesman, & Eryilmaz, 2010; Yang, & Li, 2017), the scoring rules were defined in **Table 1**.

The NSTTT includes the choice of answer and reason, so the scoring rules were described as follows:

1. If the answer was correct, then 4 point was given; if the selection of reason was the number sense-based method, then 4 more point was given; if the selection of reason was the rule-based method, then 2 more points was given; if the selection of reason was a misconception, then 1 more point was given; if the selection of reason was a guess, then 0 points were given.
2. If the answer was incorrect, then 0 more points were given.

Based on the earlier studies, students' significant misconceptions were examined (Caleon, & Subramaniam, 2010; Tan, Goh, Chia, & Treagust, 2002; Yang, & Li, 2017). These significant misconceptions are associated with the incorrect first two-tier options that are selected by at least 10% of the sample fifth graders (Caleon, & Subramaniam, 2010; Tan et al., 2002). Students' confidence ratings with their significant misconceptions were computed. In addition, the significant misconceptions were divided into two different categories: genuine misconceptions and spurious misconception, according to the study of Caleon and Subramaniam (2010) in the science education. If the mean confidence ratings associated with the significant misconceptions are above 3, then the significant misconceptions are defined as genuine misconceptions. If the mean confidence ratings associated with the significant misconceptions are below 3, then the significant misconceptions are defined as spurious misconceptions (Caleon, & Subramaniam, 2010). This will help us to identify whether sample students have real misconceptions or lack of knowledge which demanding more attention in further remedial instructions and research studies (Yang, & Li, 2017).

Students' incorrect responses on the both-tier test over 18.3% (1/12 + 10%) were defined as significant misconceptions in the present study (Yang & Li, 2017). Based on the earlier studies, the mean confidence associated with the significant misconceptions above 2.9 (out of 5) (Caleon, & Subramaniam, 2010; Yang & Li, 2017) were defined as genuine misconceptions. Moreover, moderate and strong misconceptions are genuine misconceptions expressed with medium level (between 2.9 and 3.3) and high level (3.3 and above) of mean confidence, respectively (Caleon, & Subramaniam, 2010; Yang, & Li, 2017). In addition, the mean confidence ratings associated with the significant misconceptions below 2.9 (out of 5) were defined as spurious misconceptions (Caleon, & Subramaniam, 2010; Yang, & Li, 2017). According to the definitions, it helps this study identify whether sample students have real misconceptions or lack of knowledge which demanding more attention in further remedial instruction and research studies.

Procedures

The data was collected through an on-line test. This test was divided into two parts (Part I and Part II) and each part included 20 questions. Each question includes the answer choice, reason choice, and confidence choice and the time limits are within forty seconds, sixty seconds, and twenty seconds, respectively. Therefore, each question needs 120 seconds and each part needs about 45 minutes to complete the on-line test (Yang, & Li, 2017).

Reliability and Validity

The Cronbach's α coefficients of the three-tier test for each number sense component and the whole test are .856, .840, .873, .857, .823, and .902 (Yang, & Li, 2017). The results of the SEM-based construct reliability of the three-tier test on each component and the whole test are .827, .836, .840, .828, .839, .905 (Yang, & Li, 2017). Authors' study also showed that the three-tier test has good content validity and construct validity.

Table 2. The results of HK and Taiwan students' performance on number sense three-tier test

Component	Number of Item	Mean of both-tiers (Correct %) HK5 (N=125)	HK6 (N= 942)	TW5 (N=819)	SD HK5	HK6	TW5	Mean of confidence (SD) HK5	HK6	TW5
C1	8	36.18 (56.53%)	35.89 (56.08%)	27.90 (43.60%)	13.00	14.27	15.48	4.50 -1.03	4.30 -1.14	4.07 -1.2
C2	8	41.38 (64.66%)	39.80 (62.19%)	35.32 (55.19%)	14.14	12.05	12.03	4.63 -0.89	4.41 -1.07	4.22 -1.15
C3	8	37.83 (59.11%)	36.92 (57.69%)	28.43 (44.2%)	13.98	15.50	15.70	4.41 -1.11	4.22 -1.9	4.01 -1.23
C4	8	36.46 (56.98%)	32.51 (50.79%)	26.54 (41.46%)	14.01	12.40	12.75	4.49 -1.07	4.27 -1.17	4.13 -1.18
C5	8	27.71 (43.30%)	27.56 (43.06%)	26.85 (41.95%)	12.61	12.33	12.53	4.39 -1.13	4.17 -1.22	4.13 -1.17
Total Scores		**179.57 (56.12%)**	**172.68 (53.96%)**	**145.04 (45.32%)**	**57.36**	**55.34**	56.40	**4.47** -1.05	**4.27** -1.16	4.12 -1.19

Note. C1: Being able to understand the basic meaning of numbers and operations; C2: Being able to recognize the number size; C3: Being able to use multiple representations of numbers and operations; C4: Being able to recognize the relative effect of operations on numbers; C5: Being able to judge the reasonableness of a computational result via different strategies.

Table 3. The results of ANOVA test among students' performance on both-tiers and confidence, and the results of post hoc test of Scheffe among HK5, HK6, and TW5

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	61.07	2	30.54	62.45	**0**
Within Groups	920.70	1883	0.49		
Total	981.77	1885			

	(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	Upper Bound
Scheffe	HK6	HK5	-0.100373	0.066564	0.321	-0.26343	0.06269
		TW5	.347975*	0.033408	0	0.26614	0.42981
	HK5	HK6	0.100373	0.066564	0.321	-0.06269	0.26343
		TW5	.448348*	0.067147	0	0.28386	0.61284
	TW5	HK6	-.347975*	0.033408	0	-0.42981	-0.26614
		HK5	-.448348*	0.067147	0	-0.61284	-0.28386

RESULTS

The Differences on the NSTTT between Hong Kong and Taiwan Students

Table 2 reports the results of HK and Taiwan students' performance on number sense 3-tier test. Data show that HK 5th grade students performed the best on the mean scores for each number sense component and whole test. Taiwan 5th grade students performed poorly on the mean scores for each number sense component and whole test. At the same time, HK 5th graders have the highest confidence among the three groups when responding to number sense related questions. In order to examine whether the significant differences exist among the three groups on NS both-tiers test and confidence, the ANOVA was conducted.

Table 3 presents the results of ANOVA among students' performance on number sense both-tiers test and mean of confidence, and the results of post hoc test of Scheffe. Data show that there is a significant difference among the sample students (α=.05). Therefore, the post hoc test of Scheffe was done (see **Table 3**). Results show that there is a significant difference between HK 5th graders and Taiwan 5th graders, and HK 6th graders and Taiwan 5th graders at α=.05 level on the mean of both-tiers test and confidence index. This indicates that HK 5th and 6th grade students are not only significantly performed better on NS both-tiers test than Taiwan 5th grade students, but also are more confident in answering NS two-tiers test than Taiwan 5th grade students.

Table 4. The differences on the methods used by sample students

Grade	Correct				Incorrect (%)	Confidence
	Reason (%)					
	NS-based	R-based	Misconceptions	Guessing		
HK-5th	33.50%	17.36%	12.20%	4.64%	32.30%	4.65
HK-6th	33.34%	15.08%	11.57%	3.92%	36.09%	4.47
Taiwan-5th	25.57%	16.37%	10.16%	2.37%	45.53%	4.28

Table 5. The key differences on the number sense performance between HK and Taiwan students

Category	Number Sense Performance			Difference	
	HK6	HK5	TW5	HK5 – TW5	HK6 – TW5
C1-1	62%	62%	41%	21%	22%
C1-2	77%	74%	54%	20%	23%
C1-6	65%	73%	50%	23%	15%
C1-7	78%	78%	57%	21%	21%
C3-3	50%	59%	36%	24%	15%
C3-4	77%	84%	53%	**32**%	**25**%
C3-5	59%	69%	26%	**43**%	**33**%
C3-8	71%	74%	51%	22%	19%
C4-2	73%	77%	51%	26%	22%
C4-3	38%	53%	23%	30%	15%
C5-3	69%	76%	46%	30%	22%

Note. (1). The number in each cell number sense performance means the correct percentage on the first-tier test;
(2). HK5-TW5 means the difference on the on the correct percentages of number sense first-tier test between HK5 and TW5; (3). The bolded C3-5 and C3-4 as the top two items which showed the key differences on the number sense first-tier test between HK5 and TW5.

The Differences on the Methods Used by Hong Kong and Taiwan Students

Table 4 reports the results of the differences on the methods used by sample students. Data show that all of the sample students have the low percentage on the use of number sense-based method to solve number sense related questions. Only one-thirds of students could use number sense-based method to solve questions by HK 5th and 6th graders. However, only about one-fourths of students could use number sense-based method to solve questions by Taiwan 5th graders.

In addition, the results of chi-square test (df = 2, x^2 = 268.23, p < 0.0001) show that there is a significant difference in the incorrect percentages among the three groups (HK 5th, HK 6th, and Taiwan 5th). The post hoc test of Scheffe revealed that there is a significant difference in the incorrect responses between HK5 and TW5, and HK6 and TW5. This indicates that Taiwan fifth grade students performed poor on number sense than Hong Kong fifth and sixth grade students. Moreover, the chi-square test (df = 2, x^2 = 199.69, p < 0.0001) also showed that there is a significant difference in the use of NS-based method among the three groups (HK5, HK6, and TW5).

The results of post hoc tests of Scheffe further show that there is a significant difference in the use of NS-based method between HK5 and TW5, and HK6 and TW5. This indicates that Hong Kong fifth and sixth grade students are better on the use of number sense-based method when responding to number sense related questions.

The Key Differences on the Number Sense Performance between HK and Taiwan Students

Table 5 reports some items which have key differences on the correct percentages of number sense first-tier test between HK5 (Hong Kong 5th graders) and TW5 (Taiwan 5th graders), and HK6 (Hong Kong 6th graders) and TW5. Data revealed that there are 10 items over 20% differences on the correct percentages of number sense first-tier test between HK5 and TW5. It implies that there are 10 items HK5 students are 20% higher than the TW5 students. There are 7 items over 20% differences on the correct percentages of number sense first-tier test between HK6 and TW5. It means that there are 7 items HK6 students are 20% higher than the TW5 students. Moreover, there are three items that HK5 students are over 30% higher on the correct percentages of number sense first-tier test than the TW5 students. In addition, C3-5 and C3-4 are commonly ranked the top two items which have key differences on the number sense first-tier test. Furthermore, to deeply understand the key differences on the three items that HK5 students are 30% higher on the correct percentages of number sense first-tier test than the TW5 students, we presented the detailed responses results on item C3-5, C3-4, and C4-3 for HK5, HK6, and TW5.

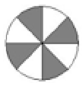
Table 6. HK5, HK6, and TW5 students' responses to item C3-5

Choices (%)				%	Reasons for Choosing Your Answer	Method
Denny			HK6	13.20%	There are four shaded parts	Misconception
	HK6	17.80%	HK5	10.40%		
			TW5	23.70%		
			HK6	2.40%	The arrow pointing in the picture of the number line is 0.8, Tom is wrong.	Misconception
	HK5	13.60%	HK5	2.40%		
			TW5	3.20%		
			HK6	2.20%	I'm guessing.	Guessing
	TW5	28.60%	HK5	0.80%		
			TW5	1.70%		
Tom			HK6	8.50%	Counting four to the right from 0 is 0.4.	Misconception
	HK6	13.90%	HK5	5.60%		
			TW5	19.40%		
			HK6	4.00%	Shaded part is $\frac{4}{8}$=0.5, Denny is wrong.	Misconception
	HK5	8.00%	HK5	2.40%		
			TW5	8.70%		
			HK6	1.40%	I'm guessing.	Guessing
	TW5	29.80%	HK5	0.00%		
			TW5	1.70%		
Both are correct	HK6	9.00%	HK6	6.60%	There are four parts are shaded, which means 0.4 and counting four to the right from 0 is 0.4.	Misconception
			HK5	9.60%		
	HK5	9.60%	TW5	14.70%		
			HK6	2.40%	I'm guessing.	Guessing
	TW5	15.40%	HK5	0.00%		
			TW5	0.70%		
*Both are false			HK6	31.90%	Shaded part is $\frac{4}{8}$=0.5 and the arrow pointing in the picture of the number line is 0.8.	Misconception
	HK6	59.20%	HK5	38.40%		
			TW5	12.30%		
			HK6	1.90%	Shaded part is $\frac{4}{4}$ and the arrow pointing in the picture of the number line is $\frac{4}{6}$, not 0.4.	Misconception
			HK5	2.40%		
	HK5	68.80%	TW5	1.60%		
			HK6	20.10%	Shaded part is $\frac{4}{8}$ and the arrow pointing in the picture of the number line is $\frac{4}{6}$, not 0.4.	NS-based
			HK5	17.60%		
			TW5	10.10%		
			HK6	5.30%	I'm guessing.	Guessing
	TW5	26.30%	HK5	10.40%		
			TW5	2.20%		

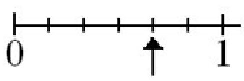
Note. * indicates the correct answer.

C3-5: Consider the decimal 0.4, which one's statement is true?

Denny: If the whole cycle is 1, then the shaded part is 0.4.



Tom: The arrow pointing in the picture of the number line



is 0.4?

C3-5 is used to examine whether students are being able to use multiple representations of numbers and its operations or not. Table 6 reports the results of HK5, HK6, and TW6 students' responses to item C3-5. Data show that the correct percentages of HK5 and HK6 are over 42.5% and 32.9% on this item than TW5 students. Results show that there are 28.6% of TW5 students believed that Denny's statement is correct. The percentage is much higher than the selection of HK5 (13.6%) and HK6 (17.8%). In further examining the selection of reason choice (2nd-tier test), we can see that 23.7% of TW5 students selected "There are four shaded parts." This is much higher than the choice of HK5 (10.4%) and HK6 (13.2%). In addition, there are 29.8% of TW5 students believed that Tom's statement is correct. This is much more serious and much higher than the selection of HK5 (8.0%) and HK6 (13.9%). In further investigating the selection of reason choice, we can see that 19.7% of TW5 students selected "Counting four to the right from 0 is 0.4." This is much higher than the choice of HK5 (5.6%) and HK6 (8.5%). Moreover, 14.6% of TW5 students believed that both statements are correct and on the reason choice they selected the "There are four parts are shaded, which means 0.4 and counting four to the right from 0 is 0.4." The percentage is also much

Table 7. HK5, HK6, and TW5 students' responses to item C3-4

Choices (%)				%	Reasons for Choosing Your Answer	Method
$3\frac{4}{12}$ meters	HK6	12.40%	HK6	8.60%	There are three 1 meter, and $\frac{1}{2}+\frac{1}{4}+\frac{1}{2}+\frac{1}{4}=\frac{4}{12}$, so the answer is $3\frac{4}{12}$ meters.	Misconception
			HK5	6.40%		
			TW5	26.10%		
	HK5	8.80%	HK6	1.20%	There are only three 1 meter, so it couldn't over 4 meters.	Misconception
			HK5	0.80%		
			TW5	2.00%		
	TW5	32.00%	HK6	2.70%	I'm guessing.	Rule-based
			HK5	1.60%		
			TW5	3.90%		
* $4\frac{2}{4}$ meters	HK6	77.40%	HK6	60.30%	There are three 1 meter, two $\frac{1}{2}$ meter, and two $\frac{1}{4}$, adding them up, then I got $4\frac{2}{4}$ meters.	NS-based
			HK5	57.60%		
			TW5	39.30%		
	HK5	84.00%	HK6	12.90%	$\frac{1}{2}+1+\frac{1}{4}+1+\frac{1}{2}+1+\frac{1}{4}=4\frac{2}{4}$, so the answer is $4\frac{2}{4}$ meters.	Rule-based
			HK5	20.00%		
			TW5	10.10%		
	TW5	52.50%	HK6	4.30%	I'm guessing.	Guessing
			HK5	6.40%		
			TW5	3.10%		
5 meters	HK6	7.90%	HK6	6.50%	There are three 1 meter, adding the others up is 2 meters, so the answer is 5 meters.	Misconception
			HK5	4.80%		
	HK5	5.60%	TW5	8.20%		
			HK6	1.40%	I'm guessing.	Guessing
	TW5	10.00%	HK5	0.80%		
			TW5	1.80%		
7 meters	HK6	2.30%	HK6	1.60%	There are 7 symbols, so the answer is 7 meters.	Misconception
			HK5	1.60%		
	HK5	1.60%	TW5	3.10%		
			HK6	0.70%	I'm guessing.	Guessing
	TW5	5.50%	HK5	0.00%		
			TW5	2.40%		

higher than HK5 (9.6%) and HK6 (6.6%). The findings show that Taiwan fifth grade students have serious misconceptions on the meaning of fractions and decimals, their relationship between fractions and decimals, and the use of multiple representations of fractions and decimals.

C 3-4: In a notation,  **represents 1 meter,**  **represents 1/2 meter,**  **represents 1/4 meter.**

What is the total meter of the notation below?

C3-4 is also used to examine whether students are being able to use multiple representations of numbers and operations or not. **Table 7** shows the results of HK5, HK6, and TW6 students' responses to item C3-4. Data show that the correct percentages of HK5 and HK6 are over 31.5% and 24.9% higher on this item than TW5 students. Results also show that there are 32.0% of TW5 students believed that the answer is $3\frac{4}{12}$ meters. The percentage is much higher than the selection of HK5 (8.8%) and HK6 (12.4%). In further examining the selection of reason choice (2nd-tier test), we can see that 26.1% of TW5 students selected." There are three 1 meter, and $\frac{1}{2}+\frac{1}{4}+\frac{1}{2}+\frac{1}{4}=\frac{4}{12}$, so the answer is $3\frac{4}{12}$meters.." This is much higher than the choice of HK5 (6.4%) and HK6 (8.6%). This finding showed that Taiwan fifth grade students have serious misconception on the addition of fractions with different denominators than Hong Kong fifth and sixth grade students. Over one-fourths of Taiwan fifth grade students believed that $\frac{1}{2}+\frac{1}{4}+\frac{1}{2}+\frac{1}{4}=\frac{4}{12}$. It is obvious that these students tried to apply the rule of the addition of whole numbers to the addition of fractions and without meaningful thinking the meanings of fractions.

Table 8. HK5, HK6, and TW5 students' responses to item C4-3

Choices (%)				%	Reasons for Choosing your Answer	Method
Student A	HK6	34.30%	HK6	20.10%	Multiplication/division takes precedence over addition/subtraction, so multiplication (5×6) should be done prior to division.	Misconception
			HK5	12.80%		
			TW5	37.10%		
	HK5	21.60%	HK6	7.60%	The bracket makes no difference to the operations. So student A's solution is the same as the problem.	Misconception
			HK5	4.80%		
			TW5	7.20%		
	TW5	48.70%	HH6	6.60%	I'm guessing.	Guessing
			HK5	4.00%		
			TW5	4.40%		
∗ Student B	HK6	38.00%	HK6	24.40%	Multiplication/division takes precedence over addition/subtraction, so multiplication (1234×6) first and division later is the same as reversing the order.	NS-based
			HK5	42.40%		
			TW5	14.90%		
	HK5	52.80%	HK6	7.90%	$1234 \div 5 \times 6 = \frac{1234}{5} \times 6$ is the same as $1234 \times 6 \div 5 = \frac{1234 \times 6}{5}$.	Rule-based
			HK5	7.20%		
			TW5	3.80%		
	TW5	22.83%	HK6	5.70%	I'm guessing.	Guessing
			HK5	3.20%		
			TW5	4.20%		
Student C	HK6	20.91%	HK6	12.20%	The order of the numbers in multiplication problems does not matter, so 5×6 can be replaced by 6×5.	Misconception
			HK5	11.20%		
			TW5	12.30%		
	HK5	21.60%	HK6	4.10%	÷5×6 and ÷6×5 are the same, 1234÷5×6= 1234÷6×5.	Misconception
			HK5	7.20%		
			TW5	4.90%		
	TW5	20.27%	HK6	4.60%	I'm guessing.	Guessing
			HK5	3.20%		
			TW5	3.60%		
Student D	HK6	6.79%	HK6	2.80%	Multiplication/division takes precedence over addition/subtraction, so multiplication (5×6) should be worked on prior to division.	Misconception
			HK5	2.40%		
			TW5	4.90%		
	HK5	4.00%	HK6	1.90%	The order of the numbers in division does not matter, so the answer will remain the same if 5×6 is placed before 1234.	Misconception
			HK5	0.00%		
			TW5	2.20%		
	TW5	8.18%	HK6	2.10%	I'm guessing.	Guessing
			HK5	1.60%		
			TW5	1.10%		

C4-3: Four students tried to solve this problem: 1234÷5×6. Whose solution is correct?

Student A: 1234÷5×6=1234÷(5×6); Student B: 1234÷5×6=1234×6÷5; Student C: 1234÷5×6=1234÷6×5; Student D: 1234÷5×6=5×6÷1234

C4-3 is used to examine whether students are Being able to recognize the relative effect of operations on numbers or not. **Table 8** shows the results of HK5, HK6, and TW6 students' responses to item C4-3. Data show that the correct percentages of HK5 and HK6 are 30.0% and 15.2% higher on item C4-3 than TW5 students. All of the sample students have higher misconceptions on this item, especially the Taiwan fifth grade students. In addition, several different misconceptions were found. For example, there are 48.7% of TW5 students believed that "Student A: 1234÷5×6=1234÷(5×6)" is correct which is much higher than the selection of HK5 (21.6%) and HK6 (34.3%). In further examining the selection of reason choice, we can see that 37.1% of TW5 students selected "Multiplication/division takes precedence over addition/subtraction, so multiplication (5×6) should be done prior to division." This is much higher than the choice of HK5 (12.6%) and HK6 (20.1%). Moreover, 7.2% of TW5, 4.8% of HK5, and 7.6% of HK6 students selected "The bracket makes no difference to the operations. So student A's solution is the same as the problem." In addition, about one-fifths of TW5, HK5, and HK6 students believed that "Student C: 1234÷5×6=1234÷6×5." In the reason choice, most of them selected: "The order of the numbers in multiplication problems does not matter, so 5×6 can be replaced by 6×5." or "÷5×6 and ÷6×5 are the same, 1234÷5×6=1234÷6×5." It seems reasonable to believe that samples students have serious misconceptions, especially Taiwan fifth grade students, which related to the effect of order of multiplication, division, and parenthesis to the final result.

The Differences of Students' Misconceptions between Hong Kong and Taiwan Students

Based on the three-tier test related studies (Caleon, & Subramaniam, 2010; Tan et al., 2002; Yang, & Li, 2017), incorrect response rates for the first and second tier that exceeded 18.3% were defined as significant misconceptions. At the same time, mean confidence scores higher than 3.3 (out of 5) that were associated with significant misconceptions were defined as strong misconceptions (Caleon, & Subramaniam, 2010; Tan et al., 2002; Yang, & Li, 2017). Data revealed Hong Kong sixth graders had strong misconceptions for 17 out of 40 items, the Hong Kong fifth graders had strong misconceptions for 18 out of 40 items, and Taiwan fifth grade students had strong misconceptions for 25 out of 40 items. It seems reasonable to believe that students from different subgroups all have serious misconceptions when responding number sense related questions. Especially, TW5 students had over a half of questions belonging to strong misconceptions which is obviously higher than the HK5 and HK6 students who had less than a half of questions belonging to strong misconceptions.

DISCUSSION AND CONCLUSION

The importance of teaching, learning, and assessment on number sense has been a line of scholarly inquiry for nearly three decades (e.g. Jones et al., 1996; Markovits, & Sowder, 1994; McIntosh et al., 1992, 1997; NCTM, 1989; Resnick, 1989; Reys, 1994; Sowder, 1992a). On the other hand, studies of students' performance on number sense provided new understanding about relationships between number sense and standard written computation, number sense and mathematics achievement, and afforded new insights into the content and framework of number sense (Aunio et al., 2004; Chen, Li, & Yang, 2015; Jones et al., 1996; Jordan et al., 2010, 2007; Markovits, & Sowder, 1994; McIntosh et al., 1997; Menon, 2004; Reys & Yang, 1998; Verschaffel et al., 2007; Yang & Li, 2008). Latterly, the design of number sense diagnostic testing system has often been viewed as a powerful tool for teaching improvement because changes in the teaching of number sense have the potential to transform classroom practice and student learning (Cai, & Howson, 2013; Chen, Li, & Yang, 2015).

Assessing and developing number sense for children has been considered as a key issue in mathematics education all over the world (Australian Education Council, 1991; Berch, 2005; Chen, Li, & Yang, 2015; Common Core State Standards for Mathematics [CCSSM], 2010; Dunphy, 2007; Hong Kong Curriculum Development Council and the Hong Kong Examinations and Assessment Authority, 2014; McIntosh et al., 1997; Ministry of Education in Taiwan, 2008; National Council of Teachers of Mathematics [NCTM], 2000; Yang & Li, 2008). The new reform-guided mathematics curricula in Hong Kong and Taiwan highlight the importance of number sense in elementary mathematics education because of its potential to develop students' flexible thinking, innovative skills, and the applied ability in the new century. However, few number senses related worked examples are found in the mathematics textbooks used by elementary school students in Hong Kong and Taiwan (Yang, & Li, 2008; Yang, & Li, 2017). This might be partially of the reason [textbook coverage could partially explain overall scores] why both Hong Kong 5th and 6th grade and Taiwan 5th grade students do not perform well on number sense as compared to their performance on international mathematics assessments (e.g. PISA and TIMSS), especially the low percentages on the use of number sense-based method when responding to number sense related questions for the Hong Kong 5th (33.50%) and 6th grade (33.4%) and Taiwan 5th grade students (25.57%). This supports the statement of Stein Stein, Remillard, and Smith (2007) that "curricula differ in significant ways and differences impact student learning" (p. 360). In fact, earlier studies have argued that mathematics textbooks are major resources for providing learning opportunities to students (Cai et al., 2011; Elliot, 2015; Fan, Zhu, & Miao, 2013; Stein et al., 2007; Tornroos, 2005; Wijaya, van den Heuvel-Panhuizen, & Doorman, 2015). Textbooks decide what, when and how mathematical content is taught, thereby affecting the learning opportunities provided to students (Reys, Reys, & Chavez, 2004; Tonroos, 2005). Mathematics textbooks employed in classrooms, in sense of mathematical content, are among the major factors that affect students' opportunities to learn mathematics (Reys et al., 2014; Tarr, Grouws, Chavez, Soria, 2013). Thus, it is reasonable to believe that Hong Kong and Taiwan students do not perform well on number sense test and low percentages on the use of number sense-based method are due to less exposure to number sense activities.

In addition, the means of confidence index are about 4.47 (out of 5) points for HK5, 4.27 points for HK6, and 4.12 points for TW5 students, which are quite high. According to the earlier studies (Hasan, Bagayoko, & Kelley, 1999; Pesman, & Eryilmaz, 2010), this indicates that sample students may have significant misconceptions or lack of knowledge related to number sense. In fact, the high confidence index and low number sense performance for the sample students may indicate that these students are overall overconfident and the strong misconceptions exist. Especially, Taiwan 5th grade students have low percentages on number sense first two-tier test that indicates TW5 students have more serious misconceptions than HK5 and HK6 students. Moreover, data revealed Taiwan fifth grade students had strong misconception for 25 out of 40 items that is higher than Hong Kong sixth graders had strong misconceptions for 17 out of 40 items and the Hong Kong fifth graders had strong misconceptions for 18 out of 40 items. This supports that Taiwan fifth grade students have more strong misconceptions when responding to number sense related questions than HK5 and HK6 students.

Findings indicate that HK 5th and 6th grade students are not only significantly performed better on NS both-tiers test than Taiwan 5th grade students, but also are more confident in answering NS two-tiers test than Taiwan 5th grade students. In addition, findings also reveal that Hong Kong fifth and sixth grade students are better on the use of number sense-based method when responding to number sense related questions than Taiwan fifth grade students. Earlier studies revealed that students' mathematics performance and confidence are closely intertwined (Alves-Martins et al., 2002; Burton, 2014; Gok, 2014), and therefore a higher confidence is predictive of higher performance (Bong & Skaalvik, 2003). House and Telese (2016) analyzed effects of confidence in mathematics and found that students who have higher confidence about their mathematics ability (e.g., usually do well in mathematics and are good at working out difficult mathematics problems) tend to show higher levels of mathematics achievement. Conversely, students who expressed lower confidence (negative appraisals) of their mathematics ability were more likely to show lower achievement test scores. The findings of this study support the argument that students who have higher confidence on mathematics tend to show higher levels of mathematics performance.

In the meantime, findings reveal that there are 10 and 7 items for HK5 and HK6 students 20% higher on the correct percentages of number sense first-tier test than the TW5 students. The big differences on the responses to item C3-5 between HK and Taiwan students show that the main misconceptions between Taiwan and Hong Kong students are different. For Taiwan students, the majority of chooses the reason "there are four shaded parts" or "counting four to the right from 0 is 0.4" or both reasons to explain their choice, while HK5 and HK6 are about one-fourths. The options indicate that the students may have wrong concept on the conversion between fraction and decimal so that they percept $\frac{4}{8}$ as 0.4 and $\frac{4}{6}$ as 0.4. It shows that most Taiwan students are unaware that the denominator needs to be the multiple of 10 to directly convert into decimals. This supports earlier studies that students don't use the representation properly to represent a fraction or decimal or place a number on a number line (Dhlamini, & Kibirige, 2014; Durkin, & Rittle-Johnson, 2015). For Hong Kong students, over half choose the correct option, but interestingly most of them choose the wrong reason. They choose the reason "Shaded part is $\frac{4}{8}$ = 0.5 and the arrow pointing in the picture of the number line is 0.8". The finding seems contradictory because the HK students showed no conceptual problem on decimal-fraction conversion in the first statement "Shaded part is $\frac{4}{8}$ = 0.5" but they answered incorrectly for the second statement. Their answer is however rated as high confidence which indicates that the problem is unrelated to lack of training on number line. The contradictory finding needs to be further investigated and while the reason provides no clues on how the students get the result of 0.8, it is best solved by asking the students on how they come up with the answer. One of the authors' perceptions on the finding is that the students may view the answer by the first instance, in which they carelessly perceive the line as being divided into 5 equal parts instead of 6. They, therefore, come up with $\frac{4}{5}$ = 0.8.

In question C3-4, HK students perform significantly better than Taiwan students and HK students shows no apparent misconception on the meaning and addition rule of fraction. For Taiwan students, about one-fourths of them come up with answer $3\frac{4}{12}$ by adding the denominator and denominator, which implies that they have serious misconception on the meaning of fraction as well as the addition rule of it. Earlier studies found that many students have misconception in fractions (see, e.g., Alghazo, & Alghazo, 2017; Ashlock, 2006; Education Development Center in USA, 2015; Trivena et al., 2017), such as adding both numerators and denominators (e.g., $1/3 + 2/5 = 3/8$). It is obvious that some Taiwan fifth grade students do not have profound understanding on adding two fractions. HK students also perform well in this question and the majority of students get the answer with number sense method. Instead of adding the fractions from left to right, these students can skillfully integrate the fractions for easier calculation. Since students are allowed to choose only one reason for their answer, it is possible that some students who are capable of using both correct method to compute the answer choose to play save by choosing the traditional rule-based one. As a result, the students who are using the number sense method may be slightly higher than the finding number.

Question C4-3 reveals very serious misconception on the calculation rule of both HK and Taiwan students. A high percentage of both group of students think that Student A/ Student C is correct. For those who choose Student A, one possible explanation for their misconception is that the rule of "multiplication/division takes precedence over addition/subtraction" is ambiguous and even quite misleading especially in Chinese, which has the literal meaning on the order of calculation as follows: 1st multiplication, 2nd subtraction, 3rd addition, 4th subtraction. As a result, they think that they should first calculate 5 x 6. One point to note is that the options "multiplication / division takes precedence over addition/subtraction" and "The bracket makes no difference to the operation" are interrelated. If students hold the thought that multiplication should be done first, then adding the bracket does not affect the answer. If this is what they think, the students are having misconception on the multiplication order rather than the usage of bracket. The students choosing Student C as their answer are probably having misconception on the rule of changing the order of multiplication/division.; they fail to acknowledge that the number should follow the sign when changing the order. It is interesting that number of students using the NS-based method to get the right answer is much higher than the rule-based counterpart. It shows that the rule on changing a fraction into the division of two numbers is not commonly aware by both HK and Taiwan students. The findings support the earlier studies that the order of operations regarding Parentheses, Exponents, Multiplication, Division, Addition and Subtraction influenced heavily on students' misconceptions in solving multiplication and division (America's Choice, 2012; Joseph, 2014).

To conclude, HK students perform better on the test than Taiwan students. However, the test reveals that the misconceptions of both groups of students (HK and Taiwan) are dissimilar. This inference matches the fact that the overall performance pattern of HK5 and HK6 students is comparable (their answering preference varies only slightly in each answer choice). This explains that the misconception is constructed not because of school year but of the curriculum/ teaching method. Further studies need to be done to investigate how the presentation of knowledge affect students' acquisition of the math concept and number sense. The authors are also thinking of a possible forth tier (the explanation tier) to investigate some answer choice of students and find out clearly their thinking processes.

In addition, the NSTTT can be easily used by elementary school teachers for the purpose of obtaining the most accurate measure of students' number sense performance, confidence, and misconceptions. Moreover, it can be used to distinguish misconceptions from a lack of knowledge in addition to the advantages of number sense two-tier tests. Besides, the NSTTT can be used for monitoring the improvement of instruction because the NSTTT scores are a valid and reliable measure of students' quantitative and qualitative understanding of number sense as well as the ability to examine the confidence level and strong misconceptions.

LIMITATIONS AND FOLLOW-UP FUTURE RESEARCH

While the 3-tier test is powerful to test whether the majority of students capture key concepts and whether or not they lack the knowledge or having wrong concepts, there are instrumental constraints. The possible "answers" are drawn by guessing the possible misconceptions of the students according to experiences, which does not show the holistic picture on the common misconceptions of all students. The method to which the students draw up their answers may not appear in the answer option. The reliability of the questions can be further strengthened by having some pre-research on the common misunderstanding of math concepts. In addition, the sample is not equally selected which is also a limitation of this study. Therefore, the generalization of the findings from this study should be cautious.

Future research is required to examine questions, such as the following: (1) How can the NSTTT help school teachers view the significance of number sense and related misconceptions? (2) How can the misconceptions found from the NSTTT help school teachers to redesign teaching materials to promote their students' number sense? (3) How can the misconceptions found from the NSTTT help school teachers to review their teaching methods and textbooks used in the classrooms?

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Effects of Digital Game-Based Experiential Learning on Students' Ethical Instruction Effectiveness

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ABSTRACT

Along with rapid advance in cities and economic structure changes, traditional family structure and concept are changing to affect learning attitudes and behavior quality to result in crises in the operation of healthy society. "Ethical instruction" therefore has become the emphasis of global education in the 21st century. The practice of ethical instruction in life allows students learning the virtue of behavior in life and stressing on the meanings of learning in practice and continued education. Gorgeous pictures, animations, and films presented on computers change children's learning methods to become easily accepting stimulating information, but not used to reading texts. Apparently, the establishment of digital games plays an important role in learning process. With nonequivalent pretest posttest control group design, 261 students of Beihua University are proceeded 15-week (3 hours per week for total 45 hours) experimental teaching in this study. The research results show significant effects of 1.digital game-based teaching on ethical instruction effectiveness, 2.experiential learning on ethical instruction effectiveness, and 3.digital game-based teaching integrated experiential learning on the promotion of ethical instruction effectiveness. According to the results, suggestions are proposed, expecting to guide learners solving problems in games so that students could solve problems by themselves to achieve autonomous learning. Besides, it allows students experiencing and learning in situations, establishing good ethics to change the attitudes and behaviors in similar situations in the future, and cultivating the concepts of responsibility, respect, concern, helping each other, cooperation, and bravery as well as healthy personality.

Keywords: digital game-based teaching, effectiveness, experiential learning, conventional morality

INTRODUCTION

The rapid advance of cities and the changes in economic structure have changed the structure and concept of traditional families. Two-paycheck families and single-parent families are increasing, the idea of gender equality is popular, and female educational attainment and socioeconomic status are enhanced that they start to walk out of families and engage in workplaces for living or other economic factors. When parents are working, the protection function of family is largely reduced that parents, due to being busy, might not find out children's deviated behaviors at the first time to correct the wrong behaviors and miss the primary time for cultivating children's correct concepts. Besides, with decreasing number of students, students are lack of interpersonal interaction at schools that the personality development is easily deviated to affect the learning attitudes and behavior quality; the operation of healthy society therefor appears crises. "Ethical instruction" therefore becomes primary in global education in the 21st century. However, ethical instruction is not a formal subject, but the integration and cultivation of attitude to life, which especially requires the match of schools, families, and society. The practice of ethical instruction in life allows students learning the virtue of behavior in life and emphasizing the meanings of learning in practice and

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Contribution of this paper to the literature

- The cooperative and discussion learning could enhance the learning climate of the class; besides, the practice of experiential learning based on digital game-based teaching could have students be more active in the knowledge learning.
- It is suggested to collect students' feedback with learning sheets, which could help teachers understand students' comprehension; especially, students with less speech and being shyness could be analyzed personal performance and course satisfaction through feedback in order to provide assistance for special conditions or attitudes.
- Teachers integrating digital game-based teaching into instruction could make learning more diversified and courses more active and interesting as well as better enhance students' learning intention and motivation.

continued education. In this case, having students experience the importance of character education could acquire the best learning outcome.

With decreasing birth rate, parents pay lots of attention to taking care of children so that children contact computers from early ages and get used to gorgeous pictures, animations, and films presented on computers. Children therefore change the learning methods and become easily to accept stimulating information, but not used to reading texts. As a result, teachers, with traditional didactic teaching, often discover that students could not concentrate on lessons. Traditional blackboard teaching stresses on teachers' one-way delivery of subject knowledge, and students passively receive knowledge. When students lose the autonomy and decision of learning, they would feel dull learning. On the contrary, students do not appear distraction and bore in the experimental lessons. Accordingly, practice opportunities and learning autonomy in the learning courses are the keys in the promotion of students' learning motivation. Learners could enhance learning motivation and effectiveness by being induced to think of solutions and strategies for reflective problems through communication, dialogue, and discrimination and to construct new knowledge through the process. Apparently, the establishment of digital games plays a critical role in learning process. Digital games are therefore utilized in this study for students' ethical instruction and discussing students' learning outcome. It is expected to guide learners' learning through solving problems in games so that students could solve problems on their own to achieve autonomous learning. Besides, each student could directly participate in. Such active learning for training problem-solving and data organization abilities could cultivate students' exploratory and innovative spirits and allow students establishing good ethics by experiencing and learning in situations. In this case, they could change the attitudes and behaviors in similar situations in the future to cultivate the concepts of responsibility, respect, concern, helping each other, cooperation, and bravery as well as healthy personality.

LITERATURE REVIEW

Digital Game-based Teaching

Games and new technology have played an important role in human life, learning, and education (Reid-Griffin & Slaten, 2016; Rocha et al., 2017; de Almeida Cruz & de Azevedo Silva, 2017; Abbasi et al., 2018). Chen and Chen (2014) defined digital game-based teaching as the "software with entertainment or education developed on computers". Manek, Shenoy, Mohan, and Venugopal (2017) defined digital games as "using electronic patterns and matching program languages to present game rules on screens". Such definitions might be different, but revealed that games were presented through computers. Jude, Kajura, and Birevu (2014) regarded digital game-based teaching as virtual reality situated learning established with games, allowing learners, as "citizens" (roles in the story), participating in the virtual situation to achieve effective learning by exchanging, interacting, and cooperating with members. It could induce learners' learning motivation and achieve the objective to cultivate comprehensive abilities with situated learning. More importantly, it allowed students learning knowledge and abilities in games and more easily transferring to real life. Atenas and Havemann (2014) stated that people learn a lot of new skills and acquire knowledge and experiences in digital game-based teaching. Game-designed education aimed to induce and foster students' creativity and allowed students applying imagination, with the experiences and knowledge in the game-based learning process, to induce "fluency", "openness", "flexibility", "uniqueness", and "elaboration" in cognition as well as cultivate "adventure", "curiosity", "imagination", and "challenge" in affection (MichelaMortara et al., 2014). Lee and Hao (2015) proposed that game-based teaching should design story situations and skills according to learning goals. Subasi, Alickovic, and Kevric (2017) mentioned that games were the method to induce learning motivation, but not the learning focus, that activities suitable for the practice at various stages and proper difficulties are designed with clearly rules, attractive situations, and understanding of learners' knowledge and skills.

Experiential Learning

Experience presents the process going through certain affairs or certain perception (Bartholomew, 2015). In other words, experiential learning is the learning process established through perceived activities in individual intrinsic world and extrinsic world, which is proceeded through thinking, perception, and physical activities (Khalid, Khalil, & Nasreen, 2014). The content of experiential learning therefore should cover following learning meanings (Agarwal & Mittal, 2014). (1) Experiential learning: learning from actual experiences. (2) Mobile learning: learning from observation, attempts, and implementation. (3) Reflective learning: reinforcing living abilities from a series of reflection. (4) Ability learning: stressing more on learning ability than knowledge acquisition in the entire learning process. Experiential learning started from experience, reflection, discussion & analysis, re-experience & analysis to the construction of internalization meaning and value. Ibáñez et al. (2014) explained experiential learning that teachers proceeded planning and discussions with students in the beginning of activities or guided students to the discussion and execution at the same time, guided students to re-think the conditions in the process after the activity, and discussing the pictures with deep impression or other ideas, and then guided the application of experience to next activity or real life. Such a run of activity and learning cycled the activity processes to generate more learning and growth. Such a process was called experiential learning circle (Sáez-López, Román-González, & Vázquez-Cano, 2014). Experiential learning aimed to provide learners with constant acquisition of direct experiences and real-time feedback; learners acquired the opportunities to apply and test learning contents, express the understanding of activities, be aware of self, develop personal interests, and enrich life experience.

Ethical Instruction Effectiveness

Cai, Wang, and Chiang (2014) described the goal and objective of ethical instruction as to guide humans doing good and cultivating good cognitive value through education, expecting to present good performance on life events. Kuo and Chao (2014) indicated that ethical instruction enhanced the society, individual responsibility and good personality traits, and moral value with strategic guidance. Molaee and Dortaj (2015) regarded ethical instruction as teaching activities composed of all education for students, teaching the value with contribution required for life and community interests. Alickovic and Subasi (2016) pointed out ethical instruction as helping students become positive and self-directed people in real life and education processes to make efforts for future directions. Shahabadi and Uplane (2014) regarded ethical instruction as the long-term process to cultivate good personality of the youth. Good ethical instruction effectiveness should contain the ideas of comprehension, helping each other, fairness, honesty, sympathy, responsibility, and respect to oneself and others. Jin, Zhao, Chow, and Pecht (2014) covered moral education, citizenship education, and personality growth and development in ethical instruction effectiveness to facilitate individuals changing the moral regulation in education and learning in the growth process. Maeng and Lee (2015) regarded ethical instruction as value education. In addition to teaching students knowing, loving, and doing good, it would shape good behaviors as personal characters. Ethical instruction effectiveness was the process internalizing learning contents conforming to social moral standards into habits.

Referring to Chao (2016), knowledge, affection, and ability are three major elements of ethical instruction. The measurement of the effectiveness of ethics development contains following dimensions.

(1) Instinctive action: Behavior motivation is resulted from physiological impulse to satisfy individual instinct basic needs. The objectives of activities might be moral, but immoral behaviors are performed at the stage.

(2) Conventional morality: Behavioral performance following existing regulations in the society. Individual behaviors would be inspected and restrained by groups, and the violation might result in punishment or exclusion.

(3) Reflective morality: Being able to criticize existing rules and regulations in the society which are followed after individual thinking. It is the moral behavior with intrinsic wisdom, rationality, and conscience.

RESEARCH HYPOTHESIS AND METHOD

Research Hypothesis

Manek et al. (2017) indicated that digital game-based teaching was considered as the teaching method which could best induce students' learning motivation, as the positive activities in games could design learning processes as interesting as games; it was an ideal learning method to effectively promote learning outcome (Uysal & Gunal, 2014). Nikou and Economides (2017) applied digital game-based teaching to learning situations to generate fun, induce children's learning motivation through the challenge and stimulation of digital games to acquire continuous sense of excitement, and further enhance learning outcome. Digital game-based teaching could break the ice between learning goals and teaching tactics as well as reduce teaching seriousness for children freely developing

Table 1. Difference analysis of digital game-based teaching

Variable	Teaching Method	Mean	F	P
instinctive action	digital game-based teaching	4.37	11.751	0.000**
	general teaching	3.26		
conventional morality	digital game-based teaching	4.15	13.426	0.000**
	general teaching	3.02		
reflective morality	digital game-based teaching	3.88	14.223	0.000**
	general teaching	2.62		

* stands for $p<0.05$ and ** for $p<0.01$

the creative thinking in the learning process. Vanderhoven et al. (2015) stated that the function and educational meanings of games were affirmed by many experts and scholars. With the fun from digital game-based teaching, children could complete learning goals in thinking and experience to achieve the learning outcome as well as satisfy the fun of gaming and learning. It therefore was the meaningful activity (Sanjay, 2016). Accordingly, the following hypothesis is proposed in this study.

H1: Digital game-based teaching shows significant effects on ethical instruction effectiveness.

Wu and Kuo (2014) produced learning situations through media or environment for students proceeding ethical instruction with the experiences. Curriculum projects like picture books, biographic story reading, newspaper reading and classic reading aloud, dramas, aphorisms, film appreciation, games, and adventure education showed remarkable effects on ethical instruction effectiveness. Ng (2016) regarded ethical instruction as the attitude to life that learning could be preceded through experience anytime anywhere; pupils therefore could present behavioral and conceptual learning which required the overall climate created by schools, families, and the entire society. Valerie (2015) mentioned that matching ethical instruction with experiential learning situation design could achieve teaching effectiveness with less effort. Romrell, Kidder, and Wood (2014) indicated that teachers could integrate existing subjects in the practice and design of ethical instruction and proceed ethical instruction with experiential learning as the body to help students cultivate core competency, induce learning interests and potential, and utilize life knowledge for the optimal learning outcome (Woo, 2014). For this reason, the following hypotheses are proposed in this study.

H2: Experiential learning shows notable effects on ethical instruction effectiveness.

H3: Digital game-based teaching integrated experiential learning reveal significant effects on the promotion of ethical instruction effectiveness.

Research Object and Research Design

To effectively achieve research objectives and test research hypotheses, nonequivalent pretest posttest control group design is applied to the experimental research. Total 261 students of Beihua University are proceeded digital game-based teaching integrated experiential learning 2╳2 experiment, which is grouped experiential learning (experiential learning, general traditional teaching) ╳ digital game-based teaching (digital game-based teaching, general traditional teaching) for 15-week (3 hours per week for total 45 hours) experimental teaching.

Analysis Method

Analysis of Variance is utilized in this study for discussing the effect of digital game-based teaching on students' ethical instruction effectiveness and the effect of experiential learning on students' ethical instruction effectiveness as well as understanding the effect of digital game-based teaching integrated experiential learning on students' ethical instruction effectiveness.

RESULT AND ANALYSIS

Difference Analysis of Digital Game-based Teaching in Ethical Instruction Effectiveness

With Analysis of Variance, the difference of digital game-based teaching in instinctive action, conventional morality, and reflective morality is discussed. From **Table 1**, digital game-based teaching and general traditional teaching show remarkable differences in instinctive action, where digital game-based teaching appears higher instinctive action than general traditional teaching. Furthermore, digital game-based teaching and general traditional teaching reveal notable differences in conventional morality, where digital game-based teaching appears higher conventional morality than general traditional teaching. Finally, digital game-based teaching and general traditional teaching reveal significant differences in reflective morality, where digital game-based teaching shows higher reflective morality than general traditional teaching that H1 is supported.

Table 2. Difference analysis of experiential learning

Variable	Teaching Method	Mean	F	P
instinctive action	experiential learning	4.42	14.184	0.000**
	general teaching	3.31		
conventional morality	experiential learning	4.05	12.631	0.000**
	general teaching	3.22		
reflective morality	experiential learning	4.41	21.586	0.000**
	general teaching	2.57		

* stands for p<0.05 and ** for p<0.01

Table 3. Difference analysis of digital game-based teaching in ethical instruction effectiveness

Variable	Instinctive Action			Conventional Morality			Reflective Morality		
	F	P	Scheffe	F	P	Scheffe	F	P	Scheffe
digital game-based teaching	11.751	0.000**	gamed-based > general	13.426	0.000**	gamed-based > general	14.223	0.000**	gamed-based > general
experiential learning	14.184	0.000**	Experiential > general	12.631	0.000**	Experiential > general	21.586	0.000**	Experiential > general
digital game-based teaching*experiential learning	26.772	0.000**	11>12>21>22	33.216	0.000**	11>21>12>22	37.625	0.000**	11>21>12>22

* stands for p<0.05 and ** for p<0.01

Difference Analysis of Experiential Learning in Ethical Instruction Effectiveness

Analysis of Variance is utilized for discussing the difference of experiential learning in instinctive action, conventional morality, and reflective morality. From **Table 2**, experiential learning and general traditional teaching shows notable differences in instinctive action, where experiential learning reveals higher instinctive action than general traditional teaching. Moreover, experiential learning and general traditional teaching appear significant differences in conventional morality, where experiential learning shows higher conventional morality than general traditional teaching. Finally, experiential learning and general traditional teaching reveal remarkable differences in reflective morality, where experiential learning appears higher reflective morality than general traditional teaching that H2 is supported.

Effects of Experiential Learning Integrated Digital Game-based Teaching

Analysis of Variance is used for discussing the difference of digital game-based teaching integrated experiential learning in students' ethical instruction effectiveness, and two-way Analysis of Variance is applied to discuss the interaction of digital game-based teaching and experiential learning to verify the enhancement of experiential learning. From **Table 3**, digital game-based teaching integrated experiential learning presents the highest instinctive action, conventional morality, and reflective morality that H3 is supported.

DISCUSSION

Teachers have to maintain students' classroom orders and arrange the review plans that the attitudes towards students are comparatively serious and strict. However, when proceeding experiential learning of ethics education with digital game-based teaching, teachers are no longer the authority in classrooms, but would shorten the teacher-student gap by making jokes with students to enhance the course climate and fun. The mutual support and encouragement among teams are enhanced to increase the trust between teachers and students. Students would actively share the happiness and frustration in life so that teachers could better understand students, make effective communications, and arrange courses to avoid deviation behaviors. After completing experiential learning of ethics education with digital game-based teaching, it is discovered that students improve the attitudes and performance on extracurricular or other off-campus teaching activities, such as praising/encouraging others, reducing the situations of not handing in homework, and being active and positive to the duties. Such behavior changes are not perceived in short time, but require long period of ethics education for the surprising growth of students. Teachers and parents should give supports and encouragement to students' positive changes in ethnic behaviors (e.g. being autonomous and polite to classmates and teachers) to further promote students' ethnic behaviors.

CONCLUSION

The research results reveal that proceeding experiential learning of ethical instruction with digital game-based teaching could improve students' behaviors and remind each other when other classmates make mistakes. Especially, students become considerate and helpful and could active concern about other students and provide assistance, the class coherence is enhanced, learning climate gets better, and the conditions of peers attacking each other with languages are improved. Proceeding experiential learning with digital game-based teaching could present positive effects on participants' ethical instruction. In addition to preset curriculum projects, accident events in lessons could be the material of opportunity education to reinforce students' concept of ethical instruction and behavioral learning. With digital game-based teaching teams, team members could exchange opinions and share experience to help promote course quality and achieve co-growth of the team. Besides, reducing the changes of course field and uncertainties to the lowest in the course practice could enhance participants' attention.

SUGGESTION

According to the research conclusion, the following suggestions are proposed in this study.

1. Regarding ethical instruction based on digital game-based teaching for experiential learning, it is discovered that students could better integrate the learned knowledge after the experience. For this reason, teachers, when instructing problem solving, should encourage students to find out solutions and discuss with peers as well as proceed teaching with accessible real cases when guiding the problem solving. The cooperative and discussion learning could enhance the learning climate of the class; besides, the practice of experiential learning based on digital game-based teaching could have students be more active in the knowledge learning.
2. In ethical instruction, situations or important concepts are chosen for deepening students' understanding of ethical instruction. It is suggested to collect students' feedback with learning sheets, which could help teachers understand students' comprehension; especially, students with less speech and being shyness could be analyzed personal performance and course satisfaction through feedback in order to provide assistance for special conditions or attitudes.
3. Students could learn through digital game-based teaching without pressure and under relaxing and interesting environment so that students are glad to participate in and enhance the learning motivation and maintain the attention. For this reason, teachers integrating digital game-based teaching into instruction could make learning more diversified and courses more active and interesting as well as better enhance students' learning intention and motivation. Digital game-based teaching could effectively induce learning motivation; however, it needs to constantly expand the materials and digital game functions to keep freshness for the continuous use of students. In this case, digital game contents should be timely updated, according to the needs of courses, to attract students and effectively induce the learning motivation.

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Effects of the Application of Mobile Learning to Criminal Law Education on Learning Attitude and Learning Satisfaction

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ABSTRACT

Changeable technology products have mobile technology be broadly applied to various fields to change people's behaviors as well as learning styles. The trend of mobile learning would greatly change teachers' teaching styles and learners' learning modes. Requirements for legal personnel are not simply in the judicial, units in the society have the requirements for the establishment of relevant legal systems as the rule of law order in society is not simply the responsibility of judges. Criminal law education in colleges therefore should aim to cultivate law profession with mission and justice personality and being able to contribute to the society. Taking a university in Beijing as the research object, 16-week experimental research (3hr per week for total 48 hours) on students of a department of the university is proceeded. The research results show significantly positive effects of 1.mobile learning on learning attitude, 2.learning attitude on learning satisfaction, and 3.mobile learning on learning satisfaction. Suggestions according to the results are proposed, expecting to enhance students' self-learning efficacy and learning satisfaction through the convenience and immediacy of mobile learning, and more importantly to promote students' learning attitudes towards law education.

Keywords: mobile learning, criminal law education, learning attitude, learning satisfaction, criminal law amendment

INTRODUCTION

With changeable technology products, mobile technology is broadly applied to various fields as banks, economic tourism, and data search in entertainment libraries. It changes people's behaviors as well as learning styles. The technological equipment of mobile devices contains Internet, computer multimedia interaction video, and distance learning, which are important tools for learning. The combination of such digitalization to form new teaching materials, through immediate experience interaction of computer technology and situational teaching contents, expands the learning field no longer being restricted to classrooms. Due to the maturity of broadband network technology and environment, traditional teaching styles are extended to the equipment at the network end, without being restricted to time and space. Moreover, the development of wireless communication technology allows expanding the practice of education and students' learning places to mobile time and space points which could not be reached with original wired network. It would greatly change the restrictions of learning environment and gradually set up the possibility of future learning classrooms. Furthermore, matching with currently complete e-learning materials and mobile personal wireless equipment, the trend of mobile learning would largely change teachers' teaching styles and learners' learning modes.

Regarding "criminal law education", basic law courses of brief introduction to criminal law or brief introduction to civil law and brief introduction to commercial law, i.e. "college general law education", are arranged in departments beyond department of law in colleges. It aims to cultivate students' concepts of law. This study focuses on the cultivation of criminal law education in colleges. It would be paranoid to set the goal of criminal law education in colleges as the cultivation of excellent judges and lawyers. It is not merely the judicial requiring for legal personnel, but units in the society have the requirements for the establishment of relevant legal systems, as it

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Contribution of this paper to the literature

- Schools should wiring the network in various departments and guarantee the speed of network bandwidth, the complete coverage and intensity of wireless signals.
- Education units should stress on the promotion of teachers' professional capability of criminal law, continuously plan systematic study, according to teachers' needs and development goal and aiming at teachers of criminal law education.
- Schools should establish observation and evaluation assessment systems for teachers making progress on the criminal law education mobile learning courses.

is not simply judges' responsibility to maintain rule of law order in the society. The goal of criminal law education in colleges therefore should cultivate law profession with mission and justice personality, and being able to contribute to the society. The instruction of criminal law knowledge should not be restricted to the subjects for occupational examinations, but should train students, based on criminal law, being able to integrate criminal law data with keen and deepening methods and to solve problems through history, philosophy, society, economic basis, and correlations. Inquiry method for criminal law education allows students proceeding criminal law education and understanding criminal law amendment with mobile devices. Integrating criminal law education into mobile learning, students' self-learning efficacy and learning satisfaction could be enhanced through the convenience and immediacy of mobile learning. More importantly, students' learning attitudes towards criminal law education could be promoted.

LITERATURE AND HYPOTHESIS

Criminal Law Amendment

People's Republic of China enacted several special criminal regulations, such as *About the Prohibition of Opium Tobacco Poisoning* and *Temporary Rules on Prohibition against the Exportation of Precious Cultural Relics and Books* in 1950, *The Procedures of the People's Republic of China for Prohibiting the State Currency from Entering or Leaving Our Country*, *Interim Regulations on Punishment for Impairment of State Currency*, *Regulations on the Punishment of Counterrevolutionaries of the People's Republic of China*, and *Law of the People's Republic of China on Guarding State Secrets* in 1951, *Regulations of the People's Republic of China for Suppression of Corruption* and *Interim Measures for Controlling Counter-revolutionaries* in 1952. Such special criminal regulations laid the foundation for the draft of *Criminal Law of the People's Republic of China.*

Criminal law amendment aims to punish criminals destroying the economic order in the socialism market and guarantee the socialism modernization going well. *Amendment to the Criminal Law of the People's Republic of China (10)* was passed at the 30th conference of the 12th National People's Congress Standing Committee of People's Republic of China on November 4th, 2017, and was hereby announced and practiced.

To punish criminal behavior of insulting national anthem and to practically maintain the seriousness of singing and using national anthem and national dignity, the second clause is added in Article 299 as

(1) "Whoever desecrates the National Flag or the National Emblem of the People's Republic of China by intentionally burning, mutilating, scrawling on, defiling or trampling upon it in a public place shall be sentenced to fixed-term imprisonment of not more than three years, criminal detention, public surveillance or deprivation of political rights.

(2) "Those who deliberately alter the lyrics or the score of the national anthem of the People's Republic of China, or perform or sing the national anthem in a deliberately distorted or derogatory manner, or insult the national anthem in any other manner, in a public venue, where the circumstances are serious, are sentenced in accordance with the provisions of the previous paragraph [*i.e.*, sentenced to fixed-term imprisonment of up to three years, short-term detention, controlled release, or deprivation of political rights."

Mobile Learning

Hawks (2014) simply explained mobile learning as applying mobile elements to e-learning so that learners could complete the learning with personal handheld devices. Abdullah and Ward (2016) defined mobile learning as proceeding electronic learning activity through the assistive devices of mobile devices, such as personal digital assistant and mobile phone. The so-called mobile assistive devices could be tablet PC, smart phone, pocket PC, personal digital assistant (PDA), Notebook, or any assistive devices or devices which could load digital information contents. In this case, whatever could cross the limits of time and space could be regarded as a kind of mobile learning. Lai and Hwang (2015) indicated that, in comparison with conventional instruction, learners in such mobile learning environment could active inquire, interact online, learn with scaffolding guidance and active inquiry, as well as timely engage in learning related activity (Baek, Zhang, & Yun, 2017). In other words, learners could download data with personal learning devices from providers, through wired or wireless networks, so that learners could utilize trivial time in life for the instant learning, e.g. commuting and waiting time of general office workers or students, during walking or exercising (Oryina & Adodolapo, 2016).

Referring to Chang et al. (2016), mobile nature contains convenience, expediency, and immediacy.

(1) Convenience: Providing learners with digital information and materials and assisting learners in acquiring knowledge through the service or equipment without being restricted to time and location.

(2) Expediency: It is a teaching strategy to achieve learners' self-construction through teaching design suitable for learners' ability, knowledge, and styles and guiding personal learning.

(3) Immediacy: Mobile learning, with devices, allows mutual communication of contents anytime anywhere through wireless network technology and learning platforms.

Learning Attitude

He, He, Cai, and Fang (2016) indicated that students' preference for learning situations would affect the learning attitude and further influence the learning effect. In order to achieve teaching effectiveness, teachers therefore had to treat students with warm, concerning, and positive attitudes as well as guide and cultivate the positive learning attitudes. Chu and Chen (2016) stated that learning attitude was students' attitudes towards school work and students' self-opinions resulted from the attitudes towards learning environment. Mosher (2016) also indicated that learning attitude was the persistent and consistent positive or negative psychological state of affective, cognitive, and behavioral learning content, environment, and process generated by learners, through personal experience and the influence of external environment, to reflect on the positive or negative performance of learning behavior. Qin, Zheng, and Li (2014) proposed learning attitude as learners presenting agreement or opposite action tendency on the cognition, situation, and comprehension of learning activity. Azeiteiro, Bacelar-Nicolau, Caetano, and Caeiro (2015) regarded learning attitude as learners' emotional tendency and the feeling about learning professional knowledge that teachers' teaching styles would affect learners' learning attitudes. Tully (2015) covered reading, notes, abstract, memory, preview, problem-solving, and time use as the elements of learning attitude, referring to the attitude towards school curricula, environment, teachers, classmates, and ego.

Referring to Lin et al. (2016), learning attitude is divided into two dimensions in this study.

(1) Intrinsic motivation: covering factors of learners' personal needs, desire, impulse, affection, and emotion. The so-called intrinsic motivation was the motivation involving in work to acquire the senses of achievement and satisfaction from the value of the work.

(2) Extrinsic motivation: including factors of incentive, objective, interests, and ambition. The so-called extrinsic motivation referred to involving in work for the benefits irrelevant to the value of the work (e.g. return, appraisal, and order).

Learning Satisfaction

Safari, Safari, and Hasanzadeh (2015) considered that the closer relationship between teachers and students would enhance students' satisfaction with teachers and the better curriculum content conforming to students' learning needs and interests could better promote students' learning satisfaction. Bedel (2015) pointed out learning satisfaction as the feeling about and attitude towards learning process; such feeling and attitude were formed by students' perceived pleasure in the learning activity or the learning process satisfying the physiological and psychological needs. Nelosn (2016) regarding learning satisfaction as good perception and positive attitude caused by learning activity being able to satisfy individual needs, i.e. learners being able to perceive learning activity satisfying personal learning needs in the learning process. Shukla and Dixit (2015) also proposed that learning satisfaction was students' feeling and attitudes, during or after learning, resulting in the pleasant or positive attitudes in mind; on the contrary, being unpleasant or appearing negative behavior in mind revealed the dissatisfaction. Bhaskaran and Swaminathan (2014) pointed out students' learning satisfaction as students' attitudes towards and feeling about various learning activities in the learning process being able to present students' preference for the learning activities.

Referring to Tseng et al. (2016), curriculum content, teaching style, and learning styles are used for measuring learning satisfaction in this study.

(1) Curriculum content: new knowledge in curricula, helpful contents, rich courses, and diverse courses.

(2) Teaching style: assignment evaluation, multimedia teaching styles, teaching activity in courses, and lively teaching styles.

(3) Learning styles: interface operation, home learning, learning time control, and repeatedly viewing course contents.

Research Hypothesis

Waheed, Kaur, Ain, and Sanni (2015) indicated that mobile learning aimed to improve the incomplete defects of conventional instruction and add virtual reality technology to enhance students learning attitude and motivation for students finding out coherent information in the situation to deepen the impression and association abilities as well as acquiring knowledge anytime anywhere with the assistance of ubiquitous context-aware learning systems. Arif et al. (2015) mentioned that teachers being familiar with the functions of digital devices and digital platforms could design mobile learning courses to induce students' active learning attitudes, enhance the learning efficiency, and promote the problem-solving ability. Mobile learning was the learning style with portable technology assisting students in effective learning or promoting learning attitude in the learning process. Hwang, Lai, and Wang (2015) discovered that mobile learning could enhance learning attitude, learning motivation, and learning achievement. Research showed that mobile learning model should take learning process in authentic environment into account and combine proper learning strategies or design learning activity to achieve the ideal knowledge construction. Accordingly, the following hypothesis is proposed in this study.

H1: Mobile learning presents significantly positive effects on learning attitude.

Research on the relationship between students' learning attitude and learning satisfaction, learning performance in network teaching (Yang et al., 2015) revealed that students with more network experiences in thinking and analysis presented higher learning satisfaction and learning performance and were gladder to learn the network teaching courses. In other words, the better learning attitude towards network courses would appear higher learning satisfaction. Dai (2015) regarded the positive correlation between learning attitude and professional growth in professional continuation education. That is, the higher situation of nursing staff participating in continuation education would show the better professional performance; the more rewards offered by the served units would enhance the learning attitude, revealing certain degree of satisfaction of learners. Zuber (2016) proved the remarkable correlations between learning attitude and learning satisfaction of students in computer-aided design course. Hwang and Wu (2014) proposed the notably positive correlation between learning attitude and learning satisfaction of vocational high school students in the teaching cooperation. The following hypothesis is therefore proposed in this study.

H2: Learning attitude shows remarkably positive effects on learning satisfaction.

Zhou (2016) pointed out the easy operation of mobile learning in which people could access to network information through network service to facilitate the learning and enhance students' learning motivation and learning satisfaction. Johnson et al. (2015) explained that mobile learning, with the distance real-time guiding system developed in mobile phones, could instantaneously provide learning instruction and assistance aiming at the problems or difficulties in students' experience learning process to enhance the learning satisfaction and learning effectiveness. Lin et al. (2016) mentioned that mobile learning could provide learning resources anytime anywhere and enhance the effectiveness of situational learning and experiencing learning to effective promote students' learning satisfaction and learning effect and achieve the ubiquitous learning. Ray and Chakrabarti (2016) pointed out mobile learning as the learning with personal mobile handheld devices that learners in mobile learning environment could engage in learning activities anytime anywhere to effectively enhance learning efficiency and learning satisfaction. For this reason, the following hypothesis is proposed in this study.

H3: Mobile learning reveals notably positive effects on learning satisfaction.

SAMPLE AND MEASUREMENT INDICATOR

Research Sample and Object

Taking a university in Beijing as the research object, 16-week experimental research (3hr per week for total 48 hours) is applied to the students in a department. The retrieved questionnaire is analyzed the data with LISREL.

Reliability and Validity Test

The questions in this study are referred to domestic and international researchers' research questions that the questionnaire presents certain content validity. Mobile learning, learning attitude, and learning satisfaction in this study are tested the overall structural causality. The Linear Structural Relations Model analysis results reveal that the overall model fit achieves the rational range with favorable convergent validity and predictive validity. Item-to-total correlation coefficient is utilized for testing the construct validity of questionnaire contents in this study,

Table 1. Overall Linear Structural Relation analysis

Evaluation Item	Parameter/Evaluation Standard		Result	t
Preliminary fit criteria	Mobile learning	Convenience	0.633	9.41**
		Expediency	0.627	8.25**
		Immediacy	0.618	7.46**
	Learning attitude	Intrinsic motivation	0.683	11.74**
		Extrinsic motivation	0.677	10.66**
	Learning satisfaction	Curriculum content	0.694	12.58**
		Teaching style	0.706	14.16**
		Learning styles	0.715	15.22**

Note: * stands for p<0.05, ** for p<0.01, and *** for p<0.001

Table 2. Overall Linear Structural Relation analysis

Evaluation Item	Parameter/Evaluation Standard	Result	t
Fit of internal structure of model	mobile learning → learning attitude	0.841	25.47**
	learning attitude → learning satisfaction	0.872	31.64**
	mobile learning → learning satisfaction	0.866	28.32**

Note: * stands for p<0.05, ** for p<0.01, and *** for p<0.001

Table 3. Overall Linear Structural Relation analysis

Overall model fit	X2/Df	1.914
	GFI	0.976
	AGFI	0.915
	RMR	0.009

Note: * stands for p<0.05, ** for p<0.01, and *** for p<0.001

i.e. reliability analysis. The acquired item-to-total correlation coefficients are used for judging the questionnaire contents. The item-to-total correlation coefficients of the dimensions in this study are higher than 0.7, showing certain construct validity.

Reliability analysis is further proceeded to understand the reliability of the questionnaire. The formal questionnaire is developed according to the standards, and the measured Cronbach's α reliability coefficients appear in 0.70~0.90, obviously conforming to the reliability range.

ANALYSIS OF EMPIRICAL RESULT

LISREL Evaluation Indicator

LISREL (linear structural relation) model, containing factor analysis and path analysis in traditional statistics and adding simultaneous equations in econometrics, could calculate multi-factors and multi-causal paths. The model fit is evaluated with preliminary fit criteria, overall model fit, and fit of internal structure of model.

The data in this study are organized as below. Preliminary fit criteria, overall model fit, and fit of internal structure of model are further explained as followings.

From **Table 1**, the dimensions (convenience, expediency, immediacy) of mobile learning reach significant explanations of mobile learning ($t>1.96$, $p<0.05$), two dimensions (intrinsic motivation, extrinsic motivation) of learning attitude achieve remarkable explanations of learning attitude ($t>1.96$, $p<0.05$), and three dimensions (curriculum content, teaching style, learning styles) of learning satisfaction reach notable explanations of learning satisfaction ($t>1.96$, $p<0.05$). Apparently, the overall model in this study shows favorable preliminary fit criteria.

From **Table 2**, mobile learning shows positive and significant correlations with learning attitude (0.841, $p<0.01$), learning attitude reveals positive and remarkable correlations with learning satisfaction (0.872, $p<0.01$), and mobile learning appears positive and notable correlations with learning satisfaction (0.866, $p<0.01$) that H1, 2, and 3 are supported.

Table 3 shows that the overall model fit standards $\chi 2/Df=1.914$, smaller than the standard 3, and RMR=0.009 that both $\chi 2/DF$ and RMR are appropriate. Moreover, chi-square value is sensitive to sample size that it is not suitable for directly judging the fit. However, the overall model fit standards GFI=0.976 and AGFI=0.915 are higher than the standard 0.9 (the closer GFI and AGFI to 1 revealing the better model fit) that this model presents good fit indicators.

CONCLUSION

The research results reveal remarkably positive effects of mobile learning on learning attitude and learning satisfaction. In this case, a school could reinforce the application of mobile learning, e.g. broadening the coverage of digital environment on campus and strengthening the signals to prevent students from reducing the e-learning learning attitude and learning satisfaction due to interruption. A school with broader and more complete e-learning equipment and environment could offer more e-learning courses for teachers involving in the supplement and production of e-learning materials. Students with higher satisfaction with the quality of network systems and learning conditions would perceive better convenience of the teaching platform. The effect of learning attitude on learning satisfaction reveals that students with good learning attitudes could enhance the learning satisfaction with criminal law learning. In this case, students with better attitudes would present better learning satisfaction and effectiveness. Apparently, mobile learning devices could lead the learning of criminal law education and allow students collecting data for criminal law education. Mobile devices are equipped applications with diverse and strong functions, with which students could collect data and integrate knowledge for criminal law education and immediately understand the latest information of criminal law amendment for the criminal law learning. The learning activity therefore becomes seamless learning mode combining authentic environment with learning contents to enhance the goal of putting learning into practice.

RECOMMENDATIONS

By organizing the results and findings in this study, practical suggestions are proposed as below.

1. Schools should wiring the network in various departments and guarantee the speed of network bandwidth, the complete coverage and intensity of wireless signals. After all, it is the basic gate for students entering digital learning mode. Academic Affair Office should continuously reward teachers for the production of digital materials and those properly uploading course related digital data, as these would rich the mobile learning contents. Such environment and contents would stimulate students' learning motivation and attitudes for better learning satisfaction.
2. Education units should stress on the promotion of teachers' professional capability of criminal law, continuously plan systematic study, according to teachers' needs and development goal and aiming at teachers of criminal law education, regularly proceed teachers' criminal law empowerment courses, or provide teachers with short-term study on criminal law related courses to present two-way communication and supplement teachers' inadequate criminal law profession. By shortening the distance between teaching theories and practice, it is expected that teachers could present higher energy on the criminal law professional development.
3. Currently, schools promote teachers' professional growth by the participation in dialogue and discussion, presentation of teaching outcomes, on-campus teaching observation, and guidance from experts and researchers, revealing that schools have held activities related to criminal law professional growth for teachers. In terms of the effectiveness evaluation of criminal law education mobile learning practice, schools focus on the participation in action research, learning outcome presentation, or on-campus observation. Some schools would collect feedback through questionnaire survey. However, there is not a complete assessment mechanism to thoroughly grasp the teaching effectiveness of criminal law education mobile learning and the revision direction. It is suggested that schools should establish observation and evaluation assessment systems for teachers making progress on the criminal law education mobile learning courses.

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Digital Badges in Education: Trends, Issues, and Cases

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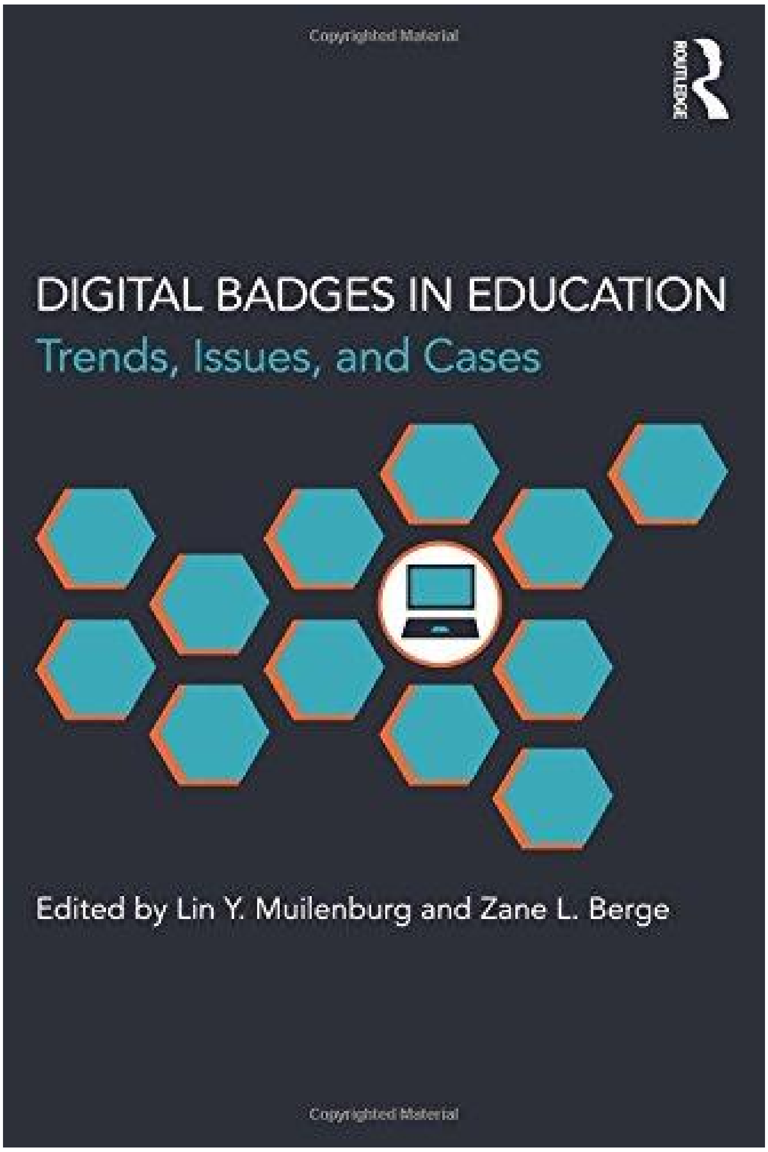
Lin Y. Muilenburg and Zane L. Berge (Eds.). Digital Badges in Education: Trends, Issues, and Cases. New York: Routledge, 2016. 288 pp. ISBN-13: 978-1138857599. US$50.30 (pbk).



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Digital badges may be alternative credentials to document and certify individuals' competency more flexibly, thereby linking the worlds of education, work and community in a meaningful way. Digital badges are designed to accurately reflect the achievements of contemporary learners and they are currently influencing educational practices. This timely book attempts to tackle this question for K12 learners, higher education courses, adult learning researchers, and people in the business.

The book's 288 pages are tightly structured around digital badges in education in twenty-five chapters, divided into two sections: Part I Trends and Issues and Part II Cases in education. The text is focused on digital badges as online-based visual representations that utilize ample metadata to signify learners' certain credentials and achievements in varied subjects. Learning design, assessment, specific cases in both academic and professional settings, and the necessary components, functions and value are explored, together with the specific problems learners face.

The authors pay attention to the history of digital badges, design philosophy, positive trends and the advantages of a badging system. Moreover, they describe the motivational function and categories of digital badges in both formal and informal education, especially higher educational settings. The real strength of this book lies in the authors' success in providing a series of abundant cases studies and building a rigorous theoretical framework for a digital badging system. Since some of the case studies may refer to different settings, readers should bear the authors' perspectives in mind and are urged to maintain those perspectives through the underlying values ascribed within each chapter.

The book begins with the history and context of open digital badges in education the badge-friendly policies, and the authors give their opinion of unbundling education and the goals of badges. Then, they analyze the consistency of open digital badges ecosystem models and cases in chapters 2 and 3 to help readers to understand ecosystem factors, rigorous assessments and credentialing systems. The link between well-defined Competency-Based Education and a robust digital badging system as a contemporary means to indicate the achievement of specific competencies in higher education is demonstrated in the next chapter. The motivational function of digital badges is explained in chapters 5 to 6 with an outline of the theoretical foundation of the design and motivation of badges. The authors explain the connection between badges and learners' motivation based on the goal achievement theory and the expectancy-value theory.

Chapters 7 and 8 contain a description of methodological design techniques and considerations with worthwhile suggestions for educational design, especially in terms of distribution frequency and time. The achievements and skill trees used in popular video games are discussed in Chapter 7, while instructional design principles from practice and experience are shared in Chapter 8 in order to provide guidelines for digital badge designs from a single badge to a "badge family".

In chapters 9 and 10, the authors demonstrate the positive trends and advantages of badge systems in both formal and informal education settings, especially in higher education. They explain the effect of a badge in practice, and explore how badges may intersect and begin to merge with other trends in education, specifically learning at scale and big data. Chapter 11 helps to understand the value, major purposes, and value priorities of badges with three main groups of different stakeholders: badge earners, issuers and badge consumers.

Chapters 12 to 15 contain cases of digital badges for K-12 learners with the aim of supporting them through college and making them ready for a career, from formal education to an informal learning environment. Empirical case studies adopted in higher education are provided in Chapters 16 to 20, including healthcare-related badges, transdisciplinary competency-based programs, a comparative analysis of customized badges and the use of modular design frameworks of badges, and badges in composition courses. The last five chapters contain cases of adult learning related to teachers' learning journey in terms of digital badge systems, the evolution of global-ready teacher badging, digital badges as a motivator in MOOCs, learning technologies badges in a teaching-related pilot phase, and continuing education in non-credit, just-in-time, short courses with a company.

The highlight of the book is a description of the digital badge instructional design considerations, which include an assessment, processes, various examples of badges and technical design considerations. Also, instructional design considerations, which include an assessment model, rewarding students who show growth in achievement, other achievement categories such as demonstrating academic behavior and performing community service, badges issued in pathways to further promote student motivation. The authors propose several key principles to improve the precision of badge movement: rigorous assessment processes, the disruptive power of badges as legitimate credentials, gamification, and collaboration among badge providers. Moreover, the book is particularly rich in examples of digital badges in both formal and informal learning.

However, the shortcomings of the book focus on its research method, which consists of almost all case studies, although the cases are spread across main state universities. Additionally, open digital badges are described in the first three chapters, but these are renamed 'digital badges' in the remainder of the book without describing how digital badges work. Moreover, the motivation levels of males and females were different based on the survey in

Chapter 12, but the strategic patterns of different genders are not explained, which may be of interest in the future. Besides, it may have better enabled readers to list the badge platforms used in the book.

The book consists of an organized review of the main digital badge themes in education, with each chapter outlining the main thinking based on the current project practices. Most authors are educational specialists, education technology providers and designers in companies, who have more experience in educational practices and the field of badge design. The aim of this book is to ask the right questions about the use of digital badges in education and, as such, it succeeds in being authoritative and friendly. Its contents are helpful and meaningful for educators to research the emerging field of digital badges.

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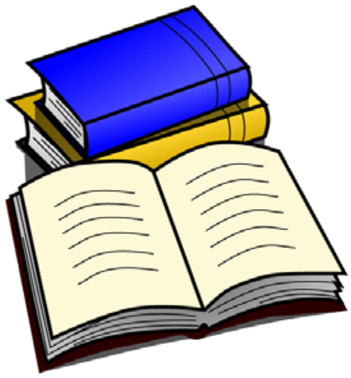

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Sustainable Environment Education in Pre-School Pupils

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ABSTRACT

"Sustainable Environmental Education" at early ages is important for creating environmental awareness. When the content of current environmental education curriculums at schools in the North Cyprus is analyzed, it is seen that only the natural environment elements are covered. Whereas environment is divided into two that are natural and the built environment. Besides the recognition and protection of the natural environment, sustainable built elements play an important role. The aim of this study is to identify through measuring the deficiency of preschool children's level of awareness of "sustainable built environment". The study was administered to 134 five year-old preschool children at a private school in the city of Nicosia by using the qualitative approach. During the study, "Interviews" were arranged and 17 questions were asked to the children. The children's level of knowledge on "sustainable built environment" was measured through a pre-test. According to the results obtained, the children are familiar with natural elements such as the trees, animals and water around their environment but are not familiar with basic building elements or related sustainable systems such as wind turbine (25.37%), solar panels (13.43%) and green roof (8.20%). These results show us the the lack of "sustainable built environment education".

Keywords: preschool, sustainable environment education, built environment

INTRODUCTION

Today children are distancing themselves from nature more and more due to the effects of the urbanization. According to the data of the United Nations Population Department, by 2025, in developing countries, 10 out of 6 children will be obligated to live in urbanized areas (Tandoğan, 2014). Whereas humans are part of nature and are inseparable. Making good relations with nature depends on people's understanding. Therefore, the suitable time for this is early childhood period. The reason for this is the information obtained in this period will influence their future lives (Kavak & Coşkun, 2017). Neurological explanations are also possible for this.

In short, the human brain is formed of the upper brain straight below is the subconscious and lower brain. Humans are born with four million years of knowledge about the universe in their lower brain. The very first information learned is formed through the upper brain and it's reserved in the subconscious. This period lasts until approximately the age of six where the subconscious is closed and the upper brain becomes active. Before the subconscious is closed, the knowledge gained within the six-year period is important and has an effect on the human throughout life (Çukur & Özgüner, 2008). For this reason, the study group we chose for the research is preschool children at the age of five who have not yet reached the age of six.

Educationist very effective to determine the quality of life for an individual in the society. The place and building in which education takes place constitutes good habitual materials (İslamoğlu, 2017). In this context in the preschool period, education integrates with environment to form awareness towards environment in the future as fundamentals of "willing behaviour" (Erten, 2004). Sontay, Gökdere, and Usta (2014), in their study, mentioned

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Contribution of this paper to the literature

- Emphasizing the awareness of environmental education at preschool which is divided into two, “natural and built” environment.
- To provide awareness of children’s knowledge about architecture at early age in preschool environment.
- By emphasizing the awareness of the “educational role” of the school buildings, children are encouraged to use the buildings for environmental education.
- To provide children with the recognition of the built environment within the school environment through “playing games”.
- Not using technological development but providing the opportunity of learning through “sustainable built environment”.

about the environmental education taught to secondary school children and stated that this education should have been taught at earlier years.

Considering that the children spend most of their time at school, the knowledge they receive about nature at these early ages is extremely important (Kahyaoğlu & Yetişir, 2015). According to many researches including Nikolaeva (2008), environmental education received within the school discipline ensures results that are more positive. Basile’s (2000) research also confirms this and it is stated in the study that the consciousness towards the environment begins to take shape in preschool period. In this period, for children, the level of education and desire especially based on observations is higher.

It is insufficient when environmental education includes only natural elements. The program should be completed by including the architectural, built environment elements. The reason for this is that the environment consists of two parts that are “natural and built”. The built environmental education for children will not only teach them the building but also help them to form the strong connection with the environment (Gökmen, 2010).

It is important that the built environment education is given in formal way by integrating the curriculum in the school environment. Historically, it is known that Jaus referred to environmental education for the first time in the preschool period in 1982 (Taşkın & Şahin, 2008). When the current literature on the subject is studied, it is observed that studies that emphasize the importance of “built environment” education are carried out by occupational chambers. For example, International Architects Union (IAU) undertook studies whereas intense studies began in 2002 in Turkey in Ankara by the Chambers of Architects. Both these establishment’s aims were to transfer the meaning of urbanity, perception of places and facts of habitable environment to the children (Chamber of Architects Ankara Branch). To this day in general in TRNC, European Union funding projects have been conducted and this still continues. For example, the study named “Children Awareness of Energy and Environment Project” is one of the long-term studies conducted until March 2017, which is an applied project, funded by the EU (European Union) and supported together with the Chambers of Environment and Electrical Engineers (Gündem Kıbrıs, 2015, February 11).

In the early years of the children, it is very effective that in preschool education the children brought up are respectful in the habitat in which they live in. Preschool education institutes must ensure that the children contribute an aspect in protecting the nature and environment, have knowledge and awareness of the process of nature recycling and natural occurences (Klaar & Öhman, 2014).

While trying to adapt built environment awareness, the target age group should be well recognized and appropriate training methodologies should be selected (Green, 2015). In the study of Warburton (2003) drew attention by stating that in schools, environment education must be taught through using some materials. Besides, children learn through games (Sarı, 2011). By using the game method, suitable activity programs must be formed (Gülay & Öznacar, 2010). In this system, where children learn by playing, participating, and practicing, environmental education itself is sustainable and can take a permanent place in school curriculum (Özdemir, 2007).

In the context of learning mostly the development of environment recognition of interior places in preschool education carries importance as much as activities on exterior places (Cooper, 2015). In the study of Miller (2007) conducted in Lincoln-Nebraska, developed a current preschool education institute and named it as “Exterior classroom” and mentioned about the design and activities within this area. This area included a garden and greenhouse that the children raised and maintained vegetables, fruits, flowers and other types of plants, at the same time it was designed as an area that the children could play in. In open-air activities physical development, health, creativity and productivity type of subjects have an effect on the children. In context, school gardens and landscape designs carry a big importance. There should be a design which children can respond to learning impulse, contains different forms, is suitable for anthropometric shapes and children will be able to learn different plant and animal species. (Çukur, 2011). Alongside to all this, the factor of teachers and family must be taken into consideration during the education of built environment. Besides the attributes of the “environment education” program in the

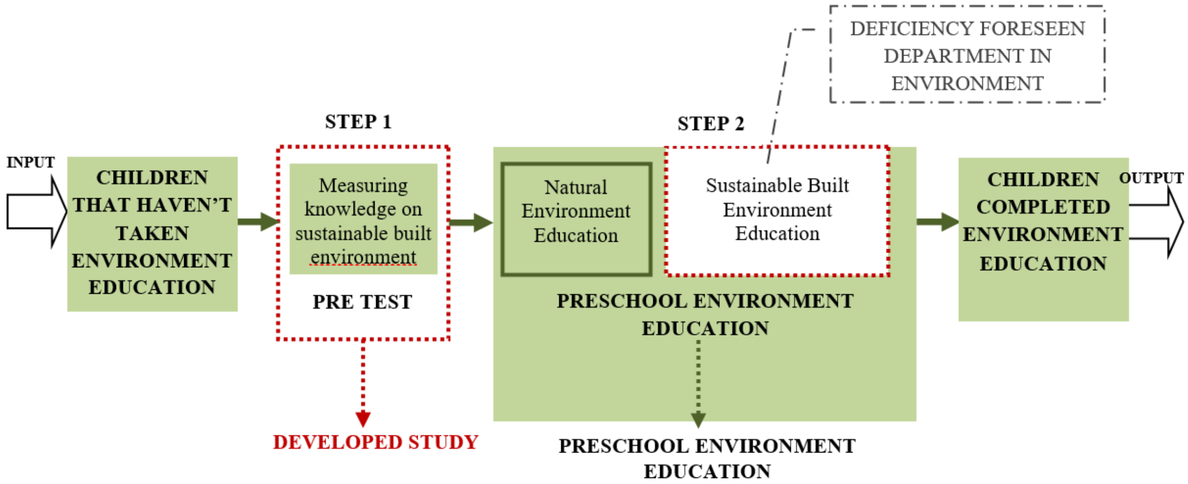


Figure 1. Diagram of preschool "environment education" content and mechanism

school environment, the role of the educator is major. As stated in the study of Esa (2010), it is necessary that in every level of education the most effective stakeholders which are the teachers must have sufficient knowledge to acquire the correct environment and sustainable awareness to the pupils within this area. On the other hand, Musser and Diamond (1999) emphasized that preschool children receiving environment education at school is as important as it is with contributions on environment education at home.

Considering today's environment issues, it will be insufficient only to include "built environment" in the education program. In the study of Kahriman-Öztürk, Olgan, and Guler (2012), the term of recycling, reducing the natural resources (such as energy / water) used, and the importance of respecting nature, must be transferred to individuals in early childhood. In context, the study aims to focus on preschool period of "sustainable built environment" education. The primary aim of current programs focusing on "natural environment" education, is to state the deficiency of children's awareness on "sustainable built environment".

METHOD

In preschool period, it is thought that environmental education given to schools is only aimed at learning and protecting "natural life". The environment, however, is not just about nature. The human-generated environment lies within and interacts with the natural environment.

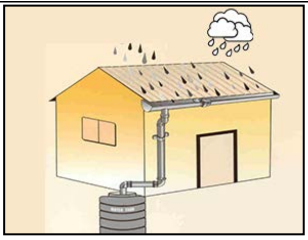
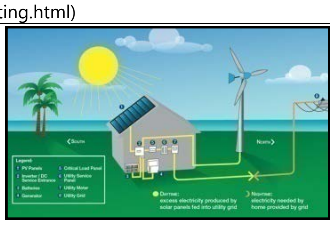
This study was conducted with the aim of measuring the "sustainable built environment" knowledge levels of 5-year-old children as built environment education has not yet entered school curriculum. The content and mechanism of the environment education program is shown as in the diagram **Figure 1**. A pre-test was administered to the children who have not yet taken the "environment education program" (step 1). In the preschool period as seen suitable in the environment education "natural" and "sustainable built environment" elements should be taught together (step 2). In this study, by using the results obtained by the pretest, in the preschool period the deficiency for "environment education program" has been identified.

This study was administered with participants of 5-year-old children studying at a private preschool. In the preschool period, the children have not yet gained reading and writing abilities. For this reason a qualitative research method for this study was administered through interviews. The interview questions were prepared in two types as "closed-ended questions" and "open-ended questions". This method was applied to obtain more rich and detailed data in order not to restrict the children with their thoughts (Böke, 2009). The questions were prepared by taking into consideration LEED "The Leadership in Energy and Environmental Design" green building certificate system that is formed of five primary criteria in order to be able to measure the level of knowledge on sustainable built environment (the fifth criterion was left out as five year old children's perception level was not found suitable). As seen in **Table 1** "LEED – Green Building Certificate System" criteria are according to the buildings sustainable features that make points and is part of the worlds most extensive system (USBGC, 2014).

Table 1. "Pre-Test" questions distribution table in context to the LEED Certificate Criteria

PRE-TEST QUESTION DISTRIBUTION ACCORDING TO THE CONTEXT OF LEED GREEN CONSTRUCTION CRITERIA CERTIFICATE SYSTEM		
1	Sustainable Sites	5 questions
2	Water Efficiency	3 questions
3	Energy Efficiency	4 questions
4	Evaluation of waste materials	5 questions
5	Indoor Quality	This criterion was not found suitable for 5 year old child's perception therefore an activity wasn't formed.
TOTAL OF 17 QUESTIONS		

Table 2. Interview questions for the children according to the LEED criteria

CRITERIA	QUESTIONS	PHOTOS	
LEED CERTIFICATE CRITERION 1: SUSTAINABLE AREAS	**QUESTION 1:** If you had the choice to play in one of these playing parks in the pictures, which would you choose? A or B		
	QUESTION 2: Why do you want to play in the play parks A or B?	**A**(http://www.yesimplastik.com.tr/62/dis-mekan-oyun-alanlari--park-)	**B** (http://www.praktyka-budowlana.pl/bezpieczny-plac-zabaw-w-ogrodzie-o-czym-pamietac/)
	QUESTION 3: What do you see in the picture?		(https://www.lindagass.com/WaterEx/Slide8.html)
	QUESTION 4: Do you have any idea what the woman in the picture is doing? Yes or No?		
	QUESTION 5: Have you heard of what green roof is? Yes or No?		
LEED CERTIFICATE CRITERION 2: EFFECTIVE WATER USE	**QUESTION 6:** Have you heard of what saving water is? Yes or No?		
	QUESTION 7: Have you heard of what collecting water is? Yes or No?		
	QUESTION 8: What do you think the children are doing in the picture?	(http://www.neoakruthi.com/rain-water-harvesting.html)	
LEED CERTIFICATE CRITERION 3: EFFECTIVE ENERGY USE	**QUESTION 9:** (The wind turbines are shown) Do you know what this is? Yes or No?		
	QUESTION 10: (The solar panels are shown) Do you know what this is? Yes or No?		
	QUESTION 11: Do you know what they are useful for? Yes or No?		
	QUESTION 12: Do you have any idea what is happening in Picture B? Yes or No?	**A**(https://www.env-news.com/energy/22994)	**B**(http://flawlessfrancis.blogspot.com.cy/)
LEED CERTIFICATE CRITERION 4: USE OF WASTE MATERIAL	**QUESTION 13:** Where do you throw your wastes?		
	QUESTION 14: Where do the wastes from the waste bin go to?		
	QUESTION 15: Can the wastes be re-used**?** Yes/No?		
	QUESTION 16: Which wastes can be re-used?		
	QUESTION 17: Do you have idea what the children are doing in the picture? Yes or No?	Compost (http://www.nrmrq.org.au/theres-a-lot-happening-in-gulf-kids-backyards/)	

The interviews with the children were conducted face to face in their own classroom environment. A total of 134 pupils from eight classes were interviewed. The interviews were completed and carried out with two experts within the field of architecture in two weeks under the supervision of the classroom teachers. The interview questions were administered after the approval of the school's education coordinator.

The children were asked 17 questions with pictures. The LEED Certificate Criteria are grouped questions as seen in Table 2.

In the early childhood period, it is important whilst making studies on measuring and evaluation that the interviewer should have a smiley face and fearless behavior towards the child (Erdoğan & Canbeldek, 2017). The children should feel safe and comfortable. In addition, a separate station was formed in the classroom of the children to carry out the interviews. Therefore, the answers they will give will show no effect on each other. The administered interviews were recorded. So that the reliability is kept high, the given data is reflected on the report exactly the same way as the data was given as in the Walcott method (descriptive analysis method) (Gürbüz & Şahin, 2014).

Data analysis: The data obtained from the pretest was evaluated in 4 separate criteria according to the LEED Green Building Certificate System. The open-ended questions for "sustainable built environment" data were formed in 3 step codes as awareness motion, unawareness motion and undecided. While the given data is being processed, the number of pupils (n) and success percentage (%) was stated.

$$\boldsymbol{Success\ percentage} = \frac{\frac{level\ of\ awareness\ motion}{unawareness\ motion}}{\frac{awareness\ motion}{unawareness\ motion} + undecided\ (= total\ number\ of\ pupils)} \times 100$$

The data was evaluated and coded separately by two experts. In order to keep the reliability high, the coherence percentage is calculated (Altunay, Oral, & Yalçınkaya, 2014).

$$\boldsymbol{Agreement\ percentage} = \frac{Coherence\ Unity}{Coherence\ Unity + Opinion\ Difference} \times 100$$

Awareness motion: The behavior of the children when they give related answers to the questions asked in the interview about "sustainable built environment".

Unawareness motion: The behavior of the children when they give non attributable answers or thought to be irrelevant to the subject while being interviewed about "sustainable built environment".

Undecided: The behavior of the children when they give answer such as "I don't know" or "I didn't understand" to the questions asked in the interview about "sustainable built environment".

FINDINGS

The pre-test (interview) administered in context to the "LEED Green Building Certificate System Criteria" data results and evaluations are stated as below.

LEED Certificate Criterion 1 "Sustainable Sites"

In the LEED Certification System, "sustainable sites" deal with a lot of things, such as the features of the piece of land where the buildings will be constructed (to be distant from the agricultural areas), the distance to the communal common areas (such as post office, hospital, school), roofing systems that have effect on the environment (green roof, etc.) (USBGC, 2014). The children were asked five questions within this criterion in order to be able to measure the level of their awareness. The answers given by the children for the interview questions are shown in **Table 3**.

Table 3. "LEED Certificate Criterion 1; Sustainable Sites" table of the level of awareness

QUESTIONS	PUPIL'S ANSWERS	MOTIONS	(n)	(%)	EVALUATION
QUESTION 1	**A** (a playground park that includes imitation materials like plastic, unnatural and has negative attributes to the environment)	**unawareness motion**	76	**56.71**	In this question it is expected that environment awareness in children would choose Picture "B" that includes natural playground toys and a playground that's formed where its nature is untouched. However, 43.29% of the children chose this playground park. Type "A" which the children chose is the playground park type that does not carry suitable attributes for the environment.
	B (a playground park that is formed of natural materials, education elements, doesn't include imitating materials that will have effect on the health of the children and it has positive attributes towards the environment)	awareness motion	58	43.29	
	"I don't know"	*undecided*	0	0	
QUESTION 2	**A** "I like these types of parks"	**unawareness motion**	32	**50.75**	In this question, it identified why the children chose the playground parks *"A"* and *"B"*. It was expected that the children choose the playground park with attributes that will not show harm to him or her or the environment. However, 40.30% of the children chose this type of park. This percentage in this subject shows a high *unaware motion* ("I have no idea" is evaluated as unaware motion).
	"It has slides, swings, etc."		31		
	"It's a large park"		2		
	"It's a colorful park"		1		
	"It has trees"		1		
	"It's a clean park"		1		
	B "It has a pool, tunnel, sand pool, tents, wooden ladders, etc." (for those who chose natural playground toys)	awareness motion	36	40.30	
	"It looks beautiful"		8		
	"It looks fun"		6		
	"There are open areas we can run"		2		
	"It's the first time I have seen a park like this"		2		
	A/B "I don't know"	*undecided*	12	8.95	
QUESTION 3	" A House"	**unawareness motion**	77	**92.53**	In this question, there is a picture of a woman building a "green roof". It was expected that when the children look at the picture they are aware and state this. However, 5.97% of the children perceived the relationship between the roof and plants that there were plants on the roof. This shows a majority of *unaware motion* about green roofs.
	"Human"		7		
	"There are people and a house"		19		
	"A house and flowers"		2		
	"A woman is planting flowers"		7		
	"There's a woman decorating the roof"		1		
	"There's a woman building a house"		8		
	"Their picking the leaves"		2		
	"A woman planting flowers on the top of the house"	awareness motion	7	5.97	
	"There are trees on the top of the house"		1		
	"I don't know"	*undecided*	2	1.50	
QUESTION 4	"The woman is building a house"	**unawareness motion**	42	**61.95**	In this question, the children were asked what the woman is doing in the picture and it is expected that they perceive the relationship between the roof and plants. However, 29.10% of the children formed this relationship. According to the percentage, it shows a majority of *unaware motion* about this subject.
	"The woman is planting something's"		15		
	"The woman is picking flowers and leaves"		13		
	"The woman is decorating the roof of the house"		8		
	"She is cleaning"		2		
	"The woman is selling flowers"		1		
	"The woman is putting a box on the roof of the house"		1		
	"She is climbing the house"		1		
	"The woman is planting/putting flowers on the roof of the house"	awareness motion	37	29.10	
	"She is building a green roof"		1		
	"She is organizing the roof"		1		
	"I don't know"	*undecided*	12	8.95	
QUESTION 5	**NO** (states the number of children who have never heard the term "green roof" before)	**unawareness motion**	123	**91.80**	In this question even though the children may not know the meaning they are asked if they have heard of the term "green roof" before. 8.20% of the children have heard this term before.
	YES (shows the number of children who may not know the meaning but they have heard the term "green roof" and those who do know)	awareness motion	11	8.20	
	"I don't know"	*undecided*	0	0	

Criterion 1 according to the results of general evaluation 25.48% awareness motion and 70.75% unawareness motion was compared. It is identified that 3.77% of the children had no idea (undecided) about the questions asked.

LEED Certificate Criterion 2 "Water Efficiency"

According to the LEED Certification System, the buildings include general water consumption, consumption reduction (saving), efficient landscape irrigation and innovative water technology systems (Erten, 2011). In this study three interview questions were prepared in order to measure the children's level of awareness towards this type of systems in the buildings. The answers the children gave for the interview questions are seen in **Table 4**.

Table 4. "LEED Certificate Criterion 2; Effective Water Use" table of the level of awareness

QUESTIONS	PUPIL'S ANSWERS	MOTION	(n)	(%)	EVALUATION
QUESTION 6	**NO** (states the number of children who have never heard the term "saving water" before)	**unawareness motion**	106	**79.10**	In this question, the level of awareness about the saving of the water systems in the building is measured. In context it was determined that 20.9% of children performed "awareness motion".
	YES (shows the number of children who may not know the meaning but they have heard the term "saving water" and those who do know)	awareness motion	28	20.90	
	"I don't know"	*undecided*	0	0	
QUESTION 7	**NO** (states the number of children who have never heard the term "collecting water" before)	**unawareness motion**	103	**76.86**	In this question, the level of awareness about the water systems used in the buildings is measured. In context it was determined that 22.38% of children performed "awareness motion".
	YES (shows the number of children who may not know the meaning but they have heard the term "saving water" and those who do know)	awareness motion	30	22.38	
	"I don't know"	*undecided*	1	0.76	
QUESTION 8	"They are pouring the water"	**unawareness motion**	32	**59.70**	In the picture of this question the children are experimenting in the school environment how to collect rain water on the roof of the building. It is expected that the children form a relationship between the roof of the building, rain water and a bucket where the answers will be evaluated according to the context. In this question, 28.35% of the children answered close to expected.
	"They are building houses"		11		
	"They are watering the roof"		7		
	"They are making a joke/game"		6		
	"They are cleaning the roof"		6		
	"They are emptying the water in a bucket"		4		
	"They are saving water"		4		
	"They are watering some things"		3		
	"They are painting the roof"		2		
	"He/she is helping their mum"		1		
	"They are filling the air with water"		1		
	"They are painting"		1		
	"They are working"		1		
	"They are pouring water"		1		
	"Someone is pouring the water the other is emptying the bucket"	awareness motion	30	28.35	
	"They are saving water"		8		
	"I don't know"	*undecided*	16	11.95	

Criterion 2 according to the results of general evaluation 23.87% awareness motion and 71.88% unawareness motion was compared. It is identified that 4.25% of the children had no idea (undecided) about the questions asked.

LEED Certificate Criterion 3 "Energy Efficiency"

A lot of importance is given to the subjects; Renewable energy sources and efficient use of energy in the buildings (Dikmen, 2011). This is also true according to the LEED Certificate. In context to this criterion, the children were asked four questions in order to measure their level of awareness towards effective energy use and renewable energy resources. The results are seen in **Table 5**.

Table 5. "LEED Certificate Criterion 3; Effective Energy Use" table of the level of awareness

QUESTIONS	PUPIL'S ANSWERS	MOTIONS	(n)	(%)	EVALUATION
QUESTION 9	**NO** (states the number of children who have never seen or heard of a "wind turbine")	**unawareness motion**	96	**71.64**	In this question, it is measured whether the children recognize the wind turbine shown in picture (A). When the answers were analyzed 25.37% of the children have heard or seen a wind turbine.
	YES (states the number of children who may not know the exact name but they have seen or heard of the word "wind turbine")	awareness motion	34	25.37	
	"I don't know"	*undecided*	4	2.99	
QUESTION 10	**NO** (states the number of children who have never seen or heard of "solar panels")	**unawareness motion**	113	**84.32**	In this question, it is measured whether the children recognize the solar panels shown in picture (A). When the answers were analyzed 13.43% of the children have heard or seen solar panels.
	YES (states the number of children who may not know the exact name but they have seen or heard the word "solar panels")	awareness motion	18	13.43	
	"I don't know"	*undecided*	3	2.25	
QUESTION 11	**NO** (states the number of children who have never known how the "solar panels" or "wind turbine" works, where it is used or what it's useful for)	**unawareness motion**	120	**89.55**	In this question, awareness level of the children was measured on the usefulness of the two important pieces of the solar panels and wind turbines. When the answers were analyzed 10.45% of children show awareness about the use of solar panels and wind turbines.
	YES ("states the number of children who can at least make a comment in context who don't know how the solar panels or wind turbines work, where they are used or what it's useful for)	awareness motion	14	10.45	
	"I don't know"	*undecided*	0	0	
QUESTION 12	**NO** (states the number of children who do not understand the relationship between renewable energy resources and the building)	**unawareness motion**	126	**94.03**	In this question, it is measured whether the children recognize or not as in picture (B) of a building that receives its energy from solar panels and wind turbines. When the answers were analyzed 5.97% of the children have heard or seen buildings with renewable energy resources.
	YES (states the number of children who relates and speaks about or tries to speak a lot about renewable energy resources and buildings)	awareness motion	8	5.97	
	"I don't know"	*undecided*	0	0	

Criterion 3 according to the results of general evaluation, 13.80% awareness motion and 84.88% unawareness motion was compared. It is identified that 4.25% of the children had no idea (undecided) about the questions asked.

LEED Certificate Criterion 4 "Evaluation of Waste Materials"

It is impossible to create a world with no waste. Therefore, it is very important how the wastes will be evaluated. Effective use of materials is an important topic today for not just at the premises, but in waste recycling and recycling in all areas (Özburak, 2017). The LEED certificate shows coherence to this criterion. Under this heading five questions were asked to the children in order to measure their awareness level. The results are as seen on **Table 6**.

Criterion 4, according to the results of general evaluation13.87% awareness motion and 78.05% unawareness motion was compared. It is identified that 8.08% of the children had no idea (undecided) about the questions asked.

Table 6. "LEED Certificate Criterion 4; "Evaluation of Waste Materials" table of the level of awareness

QUESTIONS	PUPIL'S ANSWERS	MOTIONS	(n)	(%)	EVALUATION
QUESTION 13	"Waste bin"	**unawareness motion**	132	**99.25**	In this question, children's level of awareness about waste is measured. It was stated that 99.25% of the children do not mention about waste bins or recycle bins, or even reusable.
	"Fields"		1		
	Recycle bins (paper, glass, general house waste etc.)	awareness motion	0	0	
	"I don't know"	*undecided*	1	0.75	
QUESTION 14	"To the dump"	**unawareness motion**	26	**63.43**	It was mentioned to the children that wastes are thrown in the bins, in this question asking where the wastes are taken obtained more detailed answers. 12.68% of the children mentioned about wastes being evaluated through "recycle" and "waste factory" systems.
	"Waste trucks"		25		
	"Waste bin"		19		
	"Dustbin men collect it"		11		
	"To the municipality"		1		
	"To the sea"		1		
	"To the earth"		1		
	"Gas machine"		1		
	"Waste factory"	awareness motion	5	12.68	
	"Waste machines"		2		
	"Recycle"		10		
	"I don't know"	*undecided*	32	23.89	
QUESTION 15	**NO** (states the number of children who will never reuse waste)	**unawareness motion**	86	**64.17**	In this question the children were ask the usability of waste. 34.32% average of the children is thinking that wastes can somehow be usable.
	YES(states the number of children who will reuse or recycle waste)	awareness motion	46	34.32	
	"I don't know"	*undecided*	2	1.51	
QUESTION 16	"Non are usable"	**unawareness motion**	72	**64.17**	It is important that the refuse from the buildings are separated and are either recycled or reused. The question "If we were to reuse the waste which ones would we use?" was asked to the children. According to the various answers obtained from the children show that 21.64% average say "sustainable" principles are suitable.
	"New ones"		3		
	"Clean ones"		2		
	"Empty ones"		2		
	"Odorless"		1		
	"Toys that drop on the floor"		1		
	"Non-creased ones"		1		
	"Those on the floor"		1		
	"Those we need"		1		
	"Those that are full"		1		
	"Those that can be opened"		1		
	"Papers"	awareness motion	14	21.64	
	"Bottles"		3		
	"Plastics"		2		
	"Plastics and papers"		2		
	"Other recyclables"		2		
	"Glass"		2		
	"Glass and metals"		1		
	"Bottles and cans"		1		
	"Carton and paper"		1		
	"Paper and bottles"		1		
	"I don't know"	*undecided*	19	14.19	
QUESTION 17	**NO** (states the number of children who clearly do not understand or cannot explain in the given picture what the children are doing "compost")	**unawareness motion**	133	99.25	It was measured whether the children are aware of the process of the children in the picture that they are doing "compost" or not. However, it is stated that 0.75% average of the children can form a relationship with recycling and explain it.
	YES(states the number of children who can at least understand or is aware of the relationship with recycling given in the picture of the children doing "compost")	awareness motion	1	0.75	
	"I don't know"	*undecided*	0	0	

DISCUSSION

Even though "architectural profession" may appear as an area within itself, the context of environmental education is a topic that should meet all individuals in the society. Because every individual in the society is the decision maker or practitioner on the built environment (Arın, 2014). People spend most of their day in built environments such as work place, school, residence, etc type of buildings. The World Health Organization (WHO) data also supports that humans spend 90% of their time in buildings, 70% of this in the work environment and 20% at home (Zeydan, Zeydan & Yılmaz, 2009). For this reason, it is important that they know the whole process from the construction of the building until the usage. The buildings should be explained to users (individuals) and

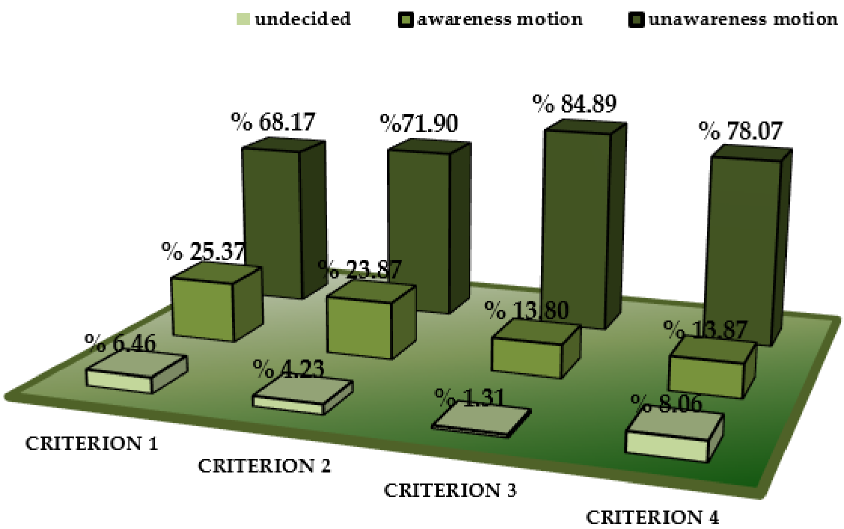


Figure 2. Table of "Sustainable built environment" awareness level of preschool children according to the LEED criteria's

"sustainable built environment awareness" should be formed so people have the right of speech when forming indoor environments, high quality, create life with respect to nature therefore it will form a protection towards the environment.

It will ensure the children in the preschool period to notice their environment, form space perceptions and recognize their built environment which they live in. Built environmental education activities include 3D. Thus strengthening the relationship of children with their physical surroundings, as well as in acquiring skills such as interrogation, relationships between systems and problem solving (Acer, 2016). It also allows for the development of coarse and fine motor movements, such as running, jumping, walking, holding, pushing, and cognitive skills, such as building relationships with the social environment, thinking scientifically, developing aesthetic perception (Gülay, 2011). Looking at the education curriculum in the preschool period it is seen that when environment education is mentioned it only includes "natural environment" elements. According to the study administered by Hedefalk, Almqvist, and Östman (2015), 87 scientific articles were analyzed and these studies focused on "natural environment", it can be clearly seen that built environment has not yet been included in education. In context, the Ministry of Education must review and renew the curriculum (Gülay & Ekici, 2010).

There are a number of scientific studies highlighting the importance of environmental education in children. Beginning in the nineties, the importance given to children's awareness of the environment and their awareness has also been reflected in the work done in this area. Lieflander, Fröhlich, Bogner, and Schultz (2013) has studied the importance of environmental education, especially the environmental education, in examining the significance and future impacts on children. On the other hand, Wilson (2010) conducted a comparative study on "Environmental Education Programs for Preschool Pupils" which put forth common aspects of nine different contents of educational programs. It is clear that in this study, natural environment education is put forward and the programs do not cover "built environment education".

CONCLUSION

This study was administered after identifying the deficiency of "environment education" in the preschool curriculum. In the study, it can be seen in the current education curriculum that the children are not able to form a connection between the buildings and natural environment *(total "unawareness motion (75.75%)* + *undecided (5.03%)"* = 80.78%). During the interviews while showing pictures, it is apparent that the children do not have sufficient amount of awareness about the use of the types of alternative energy resources green roof (8.20%), collecting of water using buildings (22.38%) and solar panels (13.43%). According to the LEED Green Building Certificate System criteria's the results of seventeen interview questions can be seen in **Figure 2.**

When interviews with children were examined in the context of sustainability criteria, it was found that children were aware that they had very little awareness (% 19.22) and that some children did unawareness motion (% 75.75) when they used houses, and (5.03) of them had no idea about sustainable built environment (see **Figure 3**).

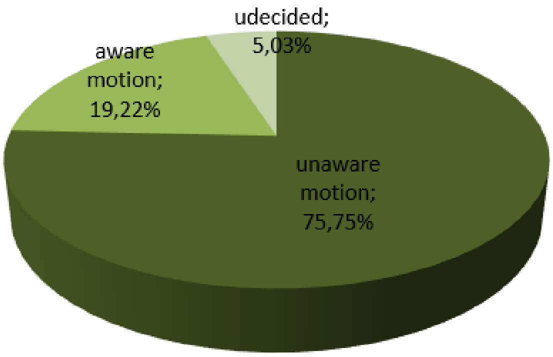


Figure 3. Children's "sustainable built environment" consciousness level in pre-school period

According to the results of the study in the preschool period it is compulsory that the environment education curriculum must be developed. The integration of curriculum in education, which will raise awareness about the buildings in which the children live and use, is important for the protection of the environment. The following are the fundamentals that can be suggested for preschool period environment lesson content.

- Environmental lesson should be organized as "natural environment" and "built environment"
- The preschool curriculums should be checked and a program of awareness towards renewable energy resources, green roof and collecting water/effective system use should be formed otherwise this deficiency should be resolved.
- The curriculum that will be prepared should not be under one perspective but a collective study with experts within this field such as architect, pedagogue and preschool teacher.

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The Place of Eucalyptus Within the Vegetation of Mesaoria Plain (Cyprus) and the Views of Vegetation Geography Lecturers

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ABSTRACT

A wide range of botanists, ecologists, foresters and geographers see eucalyptuses as a potential danger for the environment, which can be considered as an asset instead. This study includes the views that eucalyptus trees do not change the ecological environment, neither can have a major influence on it, unless the natural vegetation of an area is vastly removed and eucalyptus trees are planted in their place. In Cyprus, this is not the case, Eucalyptuses were planted individually or in small groves only in the extremely dry Mesaoria Region extending from Güzelyurt (Morpho) Bay to Mağusa (Famagusta) Bay. On the other hand, planting eucalyptus trees in the chalky and clay hills of the Mesaoria, on the dry rendzina in the Pahna formations and in the vast Flysch Series which are in contact with the southern hillsides of the Kyrenia Mountains, is indispensible for ecological support. The most important factor in the success of eucalyptus planting in Mesaoria is the extremely dry climate of the region. In this study, discussion is carried out among the the views of vegetation geography lecturers and observations around the eucalyptuses of island.

Keywords: eucalyptus, Mesaoria, Cyprus, vegetation, ecology

INTRODUCTION

The eucalyptus first came to Cyprus through the French arborist P.G. Madon. Madon, who was then sent to Cyprus in 1876 by the ottoman administration in order to prepare a report concerning the existing forests, published his first report *Replanting of island of the Cyprus* in 1880 and his second report *The preservation of the forests of the island of Cyprus* in 1881 (Yıkıcı, 2015). Both reports of Madon as well as the publication of S. Baker called *Cyprus as I saw it* indicated that in addition to the Mesaoria, the Kyrenia Mountains was also bare in Cyprus. During that period, the administration in Cyprus was taken over by the British after the Ottomans and through the utilization of political vacuum; the public were cut down the trees with an approach that would be even called a massacre. At the last quarter of 19th century, there had been almost no tree on the Kyrenia Mountains.

In Algeria, where the French arborist Madon lived for a period, the eucalyptus trees were widely used for the improvement of health conditions during the fight against malaria. Following the eucalyptus planting performed in more than thirty areas in Algeria with poor health conditions, the mortality rate from malaria dropped to first 33 in thousand by 1872 and 26 in thousand by 1876 while this figure was 46.3 in thousand between 1853-1856 (Yıkıcı,2015). With the motivation from these outcomes, Medon prepared his report following his studies in Cyprus. He indicated in his report that the species like *Eucalyptus resinifera, Eucalyptus tereticornis, Eucalyptus resdonii, Eucalyptus maculata, Eucalyptus pendulosa, Eucalyptus sideroxylon, Eucalyptus viminalis, Eucalyptus botroyides, Eucalyptus colossa, Eucalyptus occidentalis, Eucalyptus robusta, Eucalyptus persicifolia* were particularly suitable to use in the marsh areas of Cyprus. Therefore, the eucalyptus saplings were grown in the nurseries located in Nicosia and Larnaca and then used especially during the plantings in Nicosia, Famagusta and Larnaca.

Eucalyptuses have a vital role in pollen production. The number of flowering plants on the Mesaoria plain is very few. Since only some of the eucalyptus species flower during this long and dry period, the eucalyptus groves created in Mesaoria would significantly contribute to the beekeeping sector. *E. Torquata* that mainly flowers in

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Contribution of this paper to the literature

- Eucalyptus trees are suitable on the 5% of irrigable agriculture lands, as they do not bear any negative impact.
- Although it is argued that the eucalyptus tree empties the underground aquifers with its deep root systems, the results of the study and observations shows that eucalyptus species in Cyprus has no more than 4 meter-deep roots.
- Despite the structured interview results derived from Vegetation Lecturers support the idea that Eucalyptuses harm the mesaoria plain water and moist structure of the soil, the observations of the study and the figures proves the opposite that the mesaoria plain benefits from the eucalyptuses.

March-April, *E. camaldulensis, E. gomphocephala* as well as *E.woodwardii* flowering at the end of summer particularly October-November-December are the only feeding area for honey bees. According to our studies, the other species that may be important for the bee keeping are the eucalyptus species that flower at different periods of summer as *E. melliodora, E. poroza, E. leucoxylon, E. Poroza, E.odorata, E. sideroxylon*. Through the creation of eucalyptus groves with the abovementioned species in the Mesaoria plain, which has a sparse vegetation, the bee keepers would be able to continue their practices on the wide fields of Mesaoria Plain as they were changing the places of bees.

The eucalyptuses have resistance to fire. Unlike the coniferous trees, the majority of eucalyptus species are not affected by fire and they may come into leaf just after fires (Ayata,2008). Eucalyptus species possess a range of adaptive traits which provide a high resilience to the effects of fire; these may include large numbers of aerial perennating buds, a specialized subterranean regeneration organ (lignotuber), protective bark, and woody, fire-resistant seed (Wellington & Noble, 1985). Hence, among all the calabrian pines and cypress trees, tens of eucalyptus trees were come into leaf after the fire on Kyrenia Mountains in 1995. Therefore, it is important to increase the utilization rate of eucalyptuses in the places with high risk of fire and areas close to the picnic sites.

Within the framework of United Nations Environment Programme and various development programmes, the hybrid planting systems used for reforestation in many countries are promoted and the eucalyptus trees are used accordingly. However, recently some groups started to claim that it is not possible to grow anything under the eucalyptus trees and such claim was spread as a wrong opinion. Whereas the petal structure of eucalyptuses is non-rigid that allows the sunrays to pass through. Considering other tree species that form a forest or grove in Cyprus, the eucalyptus trees allow the growth of other tree or shrub more. The eucalyptus trees are the most vital accommodation point for the little birds, woodpigeon (Fassa) and raptors living in the Mesaoria Plain other than a couple of trees. According to our studies, almost all of the bushes and other tree species growing under the eucalyptuses were able to be still in place through the seeds of fruits eaten by these birds. Consequently; the natural existence of plants like the lycium (*Lycium schweinfurthii, Lycium ferocissimum),* Gonnara=wild lotus *(Zyzyphus lotus),* Buckthorn *(Rhamnus alaternus, Rhamnus oleoides)*, hawthorn *(Crataegus azarolus)*, fig *(Ficus carica)*, wild olive *(Olea oleaster)*, almond (Prunus dulcis) in the Mesaoria is related with the birds that use the eucalyptus trees for accommodation. Birds can be useful indicators for biodiversity as a whole, and the depopulated and depauperate avian community within the eucalyptus plantations will likely lead to reduced provision of many ecosystem services in this region if the spatial extent of plantations continues to expand. (Phifer, et.al, 2017)

Eucalyptus trees (Eucalyptus camaldulensis Dehnh.) can occasionally be seen in valleys at the centre of the island. (İlseven, 2017). This study aims to identify the place of eucalyptus groves within the Masaoria (İçova) Plain between the Morphou Bay and the Famagusta Bay under the vegetation of Cyprus. This study also aims to assess the effects of eucalyptus grove on the flora and fauna of Mesaoria, and the floristic features of eucalyptus and their suitability and effects of the related features from the Cyprus perspective. Together with the observations on the field face to face interviews are carried out to determine the views of the Vegetation Geography Lecturers.

METHOD

The Mesaoria Plain (İçova) was selected as the study zone, which has the surface area of 25-30 km width and 90-95 km length between the Kyrenia Mountains and Trodoos Mountains from Lefke on the west and Famagusta Bay in the east (İlseven, Hıdırer, Tümer 2016). The material of our study is particularly the eucalyptus planted during the British colonial period. Since there is not any previous (directly related) research, article and thesis regarding the areas that the eucalyptus planted, the field studies constituted the basis of our study. During the study period, the eucalyptus groves and the eucalyptus valleys in Mesaoria were visited at different times and the aim of such field visits were to determine the interaction of the eucalyptus with the local vegetation and their impact on the wild life. The eucalyptus leaf and seeds collected from the related areas were classified in accordance with the Alevkayası and the Near East University Herbarium collections and with the wide experiences of Zorlu Yıkıcı. While the plant samples were collected from the field, the plants growing at the bottom of eucalyptus trees were also identified and then found as fully compatible with the eucalyptus. The forestry maps with 1/15000 scale from the Forestry Departments of Cyprus were used.

Fifteen vegetation lecturer from different four universities of Cyprus have given their views on the eucalyptuses place in the Mesaoria.

RESULTS

Table 1. Views of Vegetation Lecturers of Eucalyptus

	Yes	No	No idea
Eucalyptuses harm the mesaiora plain water and moist structure of the soil	100%	0	0
Changes the Ecology	76%	12%	12%
Flora under the forest is changed by the Eucalyptuses	62%	25%	13%
Decrease the Bird Population	62%	13%	25%
Make the reptiles run away	50%	50%	0

After structured interviews Vegetation Lecturers support the idea that Eucalyptuses harm the mesaiora plain water and moist structure of the soil. Participants with %62 percent believe that the forest flora is badly affected because of the leaves of eucalyptus and bird population is harmed with a similar percentage. Fifty percent of the lecturers replied that reptiles are running aways from the branches of the eucalyptus.

Place of Eucalyptuses within the Ecology of Cyprus and Observations

There are 62 types of eucalyptus species identified in Cyprus, which 47 of such are classified, 15 non-classified or hybrid (Yıkıcı,2015). Out of more than 800 eucalyptus species, around 60 species were planted in the conditions of our country; when other species that are resistant to the salinity and drought are considered, there is a need to have more detailed origin trials, seed trials and researches on the production of superior genotypes through vegetative and plant tissue methods**.**

In Cyprus, the depth of aquifer in Gemikonağı is 40-50 meter, 80-100 in Yeşilyurt, 100-145 meter in Morphou. Even the absolute root depth of *Eucalyptus camaldulensis* with the deepest root systems among the eucalyptus species in Cyprus has no more than 6 meter-deep roots. While such depth may slightly vary depending on the geological structure and type of soil, our researches indicated that the average root depth of eucalyptuses is 4 m. The eucalyptus utilizes water through its hairy roots on the surface or just below the surface. In other words, the eucalyptus trees do not extract water from the deep aquifers contrary to the common belief. (See **Figure 1** and **Figure 2**) They grow well where the ground water is high. Thus, they showed good growth at the intersection of Kanlıdere, Jinnar Stream, Asi Stream and streams from Flysch through benefitting from the ground water.

Figure 1. An Eucalyptus tree in Nicosia without having deep roots

Figure 2. Eucalyptus having hairy roots in Famagusta Province

The eucalyptus utilizes water through its hairy roots on the surface or just below the surface. In other words, the eucalyptus trees do not extract water from the deep aquifers contrary to the common belief.

Değirmenlik Forests located between Haspolat - Güngör is one of the areas with major eucalyptus plantation. These meters-deep flysch fields do not have any ground water or aquifer. The sole water resource for the eucalyptus trees in this region is the low level of rainfall. Even in 2008 when the rainfall was at the minimum level, *Eucalyptus occidentalis, Eucalyptus brockwayii* and *Eucalyptus torquata* were not affected from such condition and maintained in the area and even continued sorting; the trials of Calabrian pine (*Pinus brutia*), Aleppo Pine (*Pinus halepinsus*) and Cypress trees (*Cupressus sempervirens*) showed desiccation up to 25% in the Mesaoria Plain (İlseven,2004). Even this single example explicitly shows that the eucalyptuses in Mesaoria use water effectively and grow taller more compared with other species. This is to say; the claims that the eucalyptus trees push the hydrological cycle back are unjustifiable. On the contrary, they use the same amount of water as the other species and store more carbon (Yıkıcı, 2015).

Up to now, the rate of eucalyptus trees used by the Turkish Cypriot Department of Forestry in the afforestation is not more than 2%. Almost all of them were planted on the Yazılıtepe formation, Flysch series, marly cliffs and chalky hills, which are dry and arid lands as it is not possible to grow any other species.

The Mesaoria Plain, which is suitable for the growth of eucalyptus are continuously planted for the barley farming. Since the upper part of soil that has a depth of 20-25 cm is planted without fallowing, the soils are exhausted and weakened from their mineral content. However, the deeper parts of soil have not been used and are rich in organic matter. When the fields in Mesaoria will become irrigable agricultural lands with the water pipe line project from turkey, then at least a part of the lands may be allocated for the eucalyptus trees.

The criticism that the underbrush vegetation has difficulties to grow in the eucalyptus groves is based on the lack of natural vegetation on such areas. Thus, *Lycium schweinfurthii* as a natural shrub from the Akama peninsula, Paphos, Nicosia, Larnaca and Famagusta and *Lycium ferocissimum,* an exotic species grow on lower areas under the eucalyptus trees. The eucalyptuses are precursor trees for such species and Lyciums following the eucalyptuses continue their growth. According to our studies, the Lycium bushes were found under the eucalyptus trees in the Akdeniz village on the west to the east of Mesaoria and even Karpaz Peninsula, Kavallis Forest in Yeşilköy. In addition to the poterium spinosum (*Sarcopoterium sipinosum)* as one of the garrigue vegetation components on the Flysh lands, buckthorn *(Rhamnus alaternus),* asparagus *(Asparagus stipularis)* and immortelle *(Noaea mucronata), Eucalyptus occidentalis* from West Australia as one of the shorter eucalyptus species may show natural vegetation under *Eucalyptus astringens, Eucalyptus brockwayii* and *Eucalyptus sargenti.* Even the calabrian tree can grow under the eucalyptus trees in the Değirmenlik Forest where there is no water and intensive vaporisation in summers. Young olive saplings have grown in the eucalyptus grove between the hybrid of calabrian tree (*Pinus brutia*) and Aleppo pine (*Pinus halepinsis*) in the north of Ercan Airport. These olive saplings were carried to the are with the woodpigeon and pigeons. The seeds brought by the birds were able to germinate since the spring flowing within the grove keeps the land humid during the rainfall season. Another great examples are chaste tree (*Vitex agnus-castus)* and terebinth (*Pistacia terebinthus*) growing under the eucalyptus trees along the Yedidalga Stream. Due to the luminous structure of eucalyptus trees, the related bushes had the chance to grow on the ground.

The use of eucalyptus in Mesaoria is an ecological obligation. Due to the climate structure as well as the geological and hydrological structure, there is no possibility to grow any other tree species. The trees that can grow on the chalky and clayish hills, dry rendzina caused by the Pahna formation and wide flysch series are Cyprus acacia, iron tree and eucalyptus species. No other forest species can grow in the Mesaoria (Yıkıcı,2015). The surface flow under the eucalyptus trees as individual tress or small groves planted in the past in Cyprus is slightly less than the other regions. Therefore, the eucalyptus plantations must be ensured in the steep and strong sloping dry lands in Mesaoria for the prevention of erosion.

DISCUSSION

The annual average rainfall in Mesaoria is below 340 mm. The areas that get the least rainfall in Cyprus are the Morphou Plain (286 mm), which is the western extension of this plain, and Dörtyol that located in the middle (278 mm) (İlseven, Hıdırer,Tümer 2014). Under such climatic conditions, the origin of species that might grow in the Mesaoria other than the savannah plants is Australia. Other than the eucalyptus trees (Eucalyptus Ssp.) in Mesaoria that were brought from Australia during the British administration and showed great development, the trees found in Mesaoria are Ironwood tree (*Casuarina equisetifolia*), Cyprus mimosa (*Acacia cyanophylla*) and Parkinsonia (*Parkinsonia aculeata*) (İlseven,2016).

The main reason of the successful eucalyptus planting in Mesaoria is the significantly arid climate that prevents the invasion of shrubs. This situation varies in the Kyrenia Mountains and Trodoos Mountains. The eucalyptus trees cannot resist the competition of shrubs in the areas close to the mountains in the North and South. Due to their luminous shadows, the shrubs invade the eucalyptuses when there is a slight part way through the planting in the forest zone or surrounding. In almost each spacing, the eucalyptus trees have local undergrowth bushes.

The eucalyptuses that should be considered as a great asset in terms of ecology are regarded as a potential threat for environment by many botanic, ecology, forestry and geography experts both in Cyprus and Turkey. The experts argued in their publications that the eucalyptus tree empties the underground aquifers with the deep root systems, contaminates the soil by excreting toxins, drains all the plant nutrients in the soil, cannot prevent the soil from erosion since it cannot prevent the surface flow, casts the wild animals away and have no value as animal feed and green fertilizer (Görcelioğlu1988; Amazonas et.al, 2017). However, in the results of our study and observations, even the absolute root depth of *Eucalyptus camaldulensis* with the deepest root systems among the eucalyptus species in Cyprus has no more than 4 meter-deep roots (Yıkıcı, 2015).

Figure 3. While such depth may slightly vary depending on the geological structure and type of soil, our researches indicated that the average root depth of eucalyptuses is 4 m.

As it can be seen in **Figure 2**, the eucalyptus utilizes water through its hairy roots on the surface or just below the surface. This is paralel with the studies of Ashton (1975). He finds out that in swamps, vertical roots are short and trees are very unstable.

During XVII. And XIX. centuries, eucalyptus trees were used to dry the swamps, which were the source of malaria in Cyprus, Italy, Algeria, Turkey, Israel and Uganda. Therefore, due to such features, the eucalyptus trees are mainly used to control the ground water level in the wide lands where the salinity levels of soil is high due to the high groundwater level (Görcelioğlu, 1988; De Toledo, Souza, Bertolli, S. C.,2015).

The impact of eucalyptuses on the humidity level of soil is explicit after the age of 5. Throughout the year, the groundwater deficit at the eucalyptus groves is the same with the natural forests. The main reason why eucalyptus trees are one of the exotic species preferred in an extremely dry plain like Mesaoria plain in Cyprus is its strong adaptation features. The majority of eucalyptus species developed the control mechanism that they have developed to overcome the annual dry period during the Australian rain season in Cyprus too and controlled the transpiration.

There is no difference between the impact of eucalyptus plantations on the climate and vegetation comprised of other trees or shrubs that can grow in the same ecological conditions on the climate. The eucalyptus underbrush formations can easily access to heat and rain when compared with other evergreen plants. Due to its rare branches and diathermic leaf structure, the rain and heat can easily reach to the shrub flora. Just like other vegetation formations, the eucalyptuses transform the fog to rainfall and create a positive impact on the climate. The interception loss of the eucalyptus trees are generally between 11% and 20%, which is less than pine species but more that shrub vegetation (Yıkıcı, 2015).

The eucalyptus trees may change the ecology in a country or have a major impact on the ecology only if the eucalyptus trees are planted in wide areas instead of the natural vegetation, which is not applicable for Cyprus. Eucalyptuses were only planted individually or in small groves in the extremely dry Mesaoria Region extending from Morphou Bay to Famagusta Bay. The climate condition in such a wide area is not suitable to have other shrub or undergrowth naturally other than the shrubs of *Prosopis farcta and Zizphus lotus*.

CONCLUSION

Eucalyptus trees cannot change the ecology, neither can have a major influence on it, unless the natural vegetation of an area is vastly removed and eucalyptus trees are planted in their place. In Cyprus, this is not the case. Eucalyptuses were planted individually or in small groves only in the extremely dry Mesaoria Region extending from Güzelyurt (Morpho) Bay to Mağusa (Famagusta) Bay. In majority of this vast land, the climate conditions are not suitable to naturally grow bushes or shrubs other than *Prosopis farcta and Zizphus zizyphus*.

Although the structured interview results derived from Vegetation Lecturers support the idea that Eucalyptuses harm the mesaoria plain water and moist structure of the soil, the observations of the study and the figures proves the opposite that the mesaoria plain benefits from the eucalyptuses.

In accordance with the drought conditions, the species from inland and abroad are required that grow fast for the reservation of natural forests and sustainable forestry in Cyprus. Considering the water pipe line project from Turkey, the Mesaoria Plain shows a great potential for eucalyptus plantation. As indicated by the FAO, poplar trees and eucalyptus trees are suitable on the 5% of irrigable agriculture lands, as they do not bear any negative impact.

The research studies concerning the use of waste water and sewage sludge from the Haspolat treatment plant in the eucalyptus production shall be continued, and the eucalyptus groves to be created in the region shall contribute on the fauna. The landowners that plan to plant eucalyptus trees on their lands in the Mesaoria region shall get state subsidies.

When compared with the local species, the eucalyptuses grow faster when put under the optimum conditions. The transparent and dense leaves need the inorganic matters in the soil more and consume them faster. Therefore, they are dangerous for the trees on the Kyrenia Mountains since they may deteriorate the quality of soil rich on the coastal zone where the reforestation exists. On the other hand in Mesaoria, the eucalyptus trees have a significant potential to add economic value on the inefficient areas. The eucalyptuses are the raw materials for mine pole, paper, packaging, medicine and coating industry with their wood. The flowers of eucalyptus trees may be used in the bee keeping and the trunk may be used as a windbreaker.

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An Analysis of the Professional Competencies of Turkish Language and Literature Teachers on the Basis of the Ability of Using and Managing Technology

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ABSTRACT
The purpose of this study is to reveal the importance of technology in education and to explore the professional competencies of Turkish language and literature teachers on the basis of usage and management of technology skills. In the quantitative dimension of this study, the significant difference between the opinions of Turkish language and literature teachers on the necessity of technology and their personal characteristics were examined. The qualitative dimension, on the other hand, investigated whether school managers emphasised technology usage and management skills in their expectations of Turkish language and literature teachers. The problem sentence of the study is therefore "what are the professional competencies of Turkish and literature teachers on the basis of usage and management of technology skills?" This study examines both teachers (n=99) and school managers (n=26) who worked at the secondary education level in Cyprus during the 2017-2018 academic year. A questionnaire was prepared by the researchers with the purpose of determining the technology usage status of teachers and the extent to which they believe that using technology is necessary. A semi-structured interview form was prepared in order to determine the expectations of school managers from Turkish language and literature teachers and their professional competencies. In order to be able to analyse quantitative data in the study, frequencies and percentages were used, which are descriptive statistics. Additionally, the chi-square test was applied in order to determine whether there were any differences in the answers given by teachers according to the independent variables. Content analysis was conducted in order to analyse the qualitative data. Based on the findings of the study, it can be said that teachers must accept the reality that even though they agree that technology is necessary, this opinion in fact has no value as technology is still not used. The expectations of school managers from language and literature teachers were evaluated and only a limited number of managers (only 1 student out of 26) emphasised that teachers should be competent in using technology.

Keywords: language and literature education, technology based language education, teachers professional competences, school managers opinions about technology usage, secondary school, Cyprus

INTRODUCTION

Knowledge is obtained more easily and rapidly today with the development of information technologies. Expanding rapidly to all sectors, Information technologies have also begun to be used in education (Dias Caetano & Nogueira do Nascimento, 2017; Sinchi Barbecho, Torres Pineda, & Alvarado Salinas, 2017). Used in education, schools and classrooms, information technologies bear considerable importance from the viewpoint of teachers

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Contribution of this paper to the literature

- Study includes the description of the current situation in Northern Cyprus regarding the use of technology by teachers teaching in Turkish Language and Literature.
- Turkish Language and Literature teachers and the school administrators views are taken into account to conduct an unbiased in depth analysis regarding their perceptions on Turkish Language and Literature teachers usage of technology.
- Both qualitative and quantitative studies are carried out to evaluate teachers' use of technology; additionally teachers' self-criticism regarding the use of technology, and the school administrators' critical point of view in regards to Turkish Language and Literature teachers usage of technology.

(Lawrence, 2018; Pala, 2006). Teachers today are faced with a student profile that uses information technologies with ease and mastery. For this reason, teachers must improve themselves in the field of technology. If teachers fail to improve their technology usage abilities, they cannot adapt to the improving and changing education systems. They can experience difficulty in teaching students with traditional methods and techniques in the changing education system (Aksoy, 2003; Osmani, Hindi & Weerakkody, 2018). In this context, teachers must first accept the changing technology and then they must develop and use their knowledge and technology skills. Additionally, teachers must guide students in the field of technology.

Having teachers who are interested, knowledgeable and skilful in the field of technology is not sufficient. Schools must be able to facilitate access to technological sources and manage technology effectively (Balcı, 2001; Başaran, 2000; Petko, Prasse and Cantieni, 2018). People who undertake management responsibility in education must make use of information and communication technology in the operation process of the school (Evans, 1970). The leadership and management strategies of school managers are extremely important in the effective usage of technology in schools (Weng & Tang, 2014). However, school managers who bear the responsibility of making decisions in technology-management ae majority of schools today lack the required knowledge and skills in information and communication technologies. Thus, they are not prepared to act as technological leaders in schools (Shiller, 2003). School managers have to take several decisions regarding education. These decisions increase the quality of the school when they are associated with technological infrastructure, equipment and skills (Salimi & Ghonoodi, 2012). Telem (1999) demonstrated a plan in the process of integrating information and communication technologies in institutions. This plan consisted of five sections, namely psychological, technical, structural, tools-values and managerial. The changes that occur in this direction have to pass through a process that requires attention (Yuen, Law & Wang, 2003).

Today, managers who have the capability to bring technology into schools are extremely valuable. School managers who are able to use and manage the technology well in the school and ensure that other people can also effectively use the existing technologies are called "technology leaders" (Can, 2003; Kearsley & Lynch, 1992; Shyr, 2017). A school manager who is also a technology leader must first provide opportunities to teachers, employees and students to use technology under equal terms in the school environment (Flanagan & Jacobsen, 2003). At schools, not only school managers but also teachers have to be technology leaders (Lin, 2016). In particular, school managers who are also technology leaders must control the usage of technology in activities inside and outside the classroom.

Mooij and Smeets (2001) listed five stages in the process of integrating information and communication technologies into school, which are:

1. Ensuring that all teachers access technology,
2. Demonstrating the importance of using technology in all departments and units of the school,
3. Emphasising the essence of information and communication technologies in developing new ideas,
4. Having adequate information and communication technologies equipment,
5. Incorporating technology usage in teaching and learning processes.

Technology usage, which is important for all modern courses, has become the most important instrument for accessing information. The use of technology is also highly critical in Turkish and literature teaching (Baki & Karakuş, 2012). Computers, smart boards, slides, and all kinds of audio-visual technological devices have claimed their place in the education process. This development and change has also affected Turkish courses. Today, the use of technological devices and materials in language teaching has become a necessity as it is observed that traditional methods and techniques are no longer satisfactory (Özbay, 2015; Nurova, Kharisov, Kharisova & Aitova, 2017).

The devices and instruments which will be used in Turkish and literature courses must have certain characteristics (Akyol, 2007). For example, these technological devices must be chosen according to the individual characteristics of students and the content of the course. Studies conducted by several researchers (Durukan, 2011; Melo, Mendez Batres & Martinell, 2017; Rodríguez, 2018) have emphasized the benefits of technology-assisted language and literature teaching, as follows:

1. It is a student-centred teaching approach. It ensures that students are active throughout the learning process and facilitates learning.
2. Facilitating the usage of multiple methods and techniques, it enriches learning.
3. As it addresses multiple senses of students, it ensures that learning is easier and more permanent.
4. It transfers difficult situations that cannot be easily reached by students into the learning environment and thus enables learning.
5. It guides students towards cooperative learning.
6. It enables the repetition of any topic.
7. As knowledge is transferred more systematically in a shorter period of time, teaching becomes more efficient. Learning occurs more rapidly.

According to the research findings of Yaman (2007), pre-service teachers think that technology usage makes a significant contribution to the permanency of learning in Turkish classes, the increase in the interest of students in the class, the understanding of students on covered topic, their enjoyment of the Turkish class, the development and improvement of listening skills, and the attainment of targets related to the given lesson. On the other hand, some pre-service teachers who participated in the study stated that, contrary to the positive aspects of technology, it can affect the speaking and writing skills of students negatively. The studies conducted by Şahin and Akçay (2011) and Altınok (2011) indicated that most of the Turkish language and literature teachers included in their study displayed positive attitudes towards the use of technology. Özbay (2003) claimed that education technologies such as tape recorders, radios, televisions, computers, videos and cassettes had a considerable impact on the speaking skills of students. Teachers can set an example to their students by using these instruments in language and literature courses thereby improving the students' spoken language. It is widely acknowledged that Turkish language teachers predominantly use coursebooks in their classes. A limited number of teachers make use of technological devices in order to exploit the positive effects of these instruments. It has been shown that only 4.53% of teachers used audio-visual instruments during classes, whereas 94.44% of teachers used coursebooks. Durukan's study (2011) determined that, compared to the Turkish grammar classes delivered with traditional methods, computer-assisted grammar teaching was more successful. Computer-assisted grammar teaching affected student success in a positive direction and mistakes in certain concepts decreased. Önkaş (2010) stated that technology-assisted language and literature teaching is more effective and permanent compared to traditional teaching methods. Preparing Turkish coursebooks with CD appendixes can make the teaching of speaking skills more effective. Additionally, technology saves teachers the time they lose while writing on the board and allows students to perform more practice in the topics in which they are instructed.

Durmuşçelebi (2007) examined the education, curriculum and coursebooks in the native language in a comparison of Turkey and Germany, reaching the conclusion that technology is underutilized. It was recommended that necessary arrangements should be made to support the content of Turkish course books with technological devices such as CDs, VCDs, computers and the Internet. However, several educationists (Akkoyunlu & Soylu, 2011; Kabadayı, 2006; Öner, 2006; Temur & Vuruş, 2009; Yaman & Erdoğan, 2007; Yıldırım & Tahiroğlu, 2006) stated that in technological communities, the orthographic rules, sentence and word structures and phonetic features of Turkish language are disregarded, and that Turkish is used carelessly and incorrectly. It was underlined that this problem should be addressed with care.

Arslan's study (2008) did not indicate any significant difference in terms of the computer usage of Turkish teachers based on their gender, seniority or education level. In the quantitative dimension of this study, the correlation between the opinions of Turkish and literature teachers on the necessity of technology and their personal characteristics were examined. The qualitative dimension, on the other hand, investigated whether school managers emphasised technology usage and management skills in their expectations of Turkish and literature teachers. Therefore, the purpose of this study is to reveal the importance of technology in education and to explore the professional competencies of Turkish and literature teachers on the basis of usage and management of technology skills. The problem sentence of the study is therefore "what are the professional competencies of Turkish and literature teachers on the basis of usage and management of technology skills?" Based on this problem sentence, the following sub-problems are formulated

SUB-PROBLEMS IN QUANTITATIVE RESEARCH DIMENSION

Is there any significant difference between the opinions of Turkish and literature teachers on the following items on the basis of their personal characteristics including gender, age, nationality, education level, seniority, location of the school and union membership status?

1. Being equipped with skills that a modern teacher should possess (computer, Internet …)
2. Effective, proper and accurate employment of teaching-learning strategies, methods, techniques and tactics in the learning-teaching environment,
3. Implementing multiple learning environments in the school which improve learning-oriented interaction among students and between teachers and students,
4. Implementing multiple learning environments outside the school which improve learning-oriented interaction among students and between teachers and students,
5. Directing students towards the use of diverse materials and resources.

SUB-PROBLEMS IN QUALITATIVE RESEARCH DIMENSION

What are the expectations of school managers of Turkish and literature teachers (in professional, personal terms, etc.)? Do the school managers expect language and literature teachers to be competent in using and managing technology?

METHOD

In this study, a mixture method including both qualitative and quantitative techniques has been employed. Quantitative studies examine social events by means of statistical analysis of numeric data, display cause and effect relationships, and attempt to find the rules of social systems. In other words, they are studies which collect data from broad sample groups, statistically analyse them in order to test hypotheses and attempt to generalise the obtained data (Bogdan & Biklen, 2006). On the other hand, the purpose of a qualitative study is to obtain a holistic picture instead of making generalisations. Qualitative studies attempt to examine a subject in detail and depth (Glesne, 2011). Qualitative studies have such features as perceiving and revealing events in their natural habitat with a holistic viewpoint, performing an inductive analysis, and adding flexibility to the study (Maxwell, 1996; Miles & Huberman, 1994).

The mixed research method is an approach which is based on mutual completion of qualitative and quantitative methods in terms of "depth and detail" and "generalisation and estimation" dimensions and offers the researchers a variety of options (Yıldırım & Şimşek, 2013; Johnson, Onwuegbuzie & Turner, 2007). The mixed research method is more than just a combination of qualitative and quantitative. It is a harmonisation effort that is used so that the strengths of both research methods can support each other. With this method, reaching the research findings becomes considerably easier for the researcher (Creswell & Plano Clark, 2007).

The research is based on a case study, which is a qualitative research model. In case studies, factors related to a given case are examined in detail. An attempt is made to determine how these factors affect the case examined in the study and how they are affected by the case at hand (Glesne, 2011; Yıldırım & Şimşek, 2011). The quantitative dimension of the study, on the other hand, is based on a screening model. The screening model aims to describe a case as it is. An attempt is made to define the event, individual or object which is subject of the study in its own conditions and as it is. There is no attempt to change or affect them in any way whatsoever. The important thing is the ability to observe and determine the subject being examined (Karasar, 2015).

STUDY GROUP

This study examines both teachers and school managers. No sample was taken in the quantitative dimension of the study and an attempt was made to reach the Turkish language and literature teachers who worked at the secondary education level in Cyprus during the 2017-2018 academic year (universe). Some teachers were not willing to answer the questionnaires. Some teachers could not be reached because the researchers could not find them in the school on the day of their visit. Resultantly, the quantitative dimension of the research consisted of 99 Turkish language and literature teachers. Demographic data on the teachers who participated in the study can be observed in **Table 1**.

Table 1. Distribution of teachers according to their indicative information

	Number (n)	Percentage (%)
Gender		
Female	80	80.81
Male	19	19.19
Age group		
39 years and below	26	26.26
40-45 years	34	34.34
46 years and above	39	39.39
Nationality		
North Cyprus	75	75.76
North Cyprus and Turkey	24	24.24
Education Level		
Undergraduate	81	81.82
Graduate	18	18.18
Experience		
15 years or below	51	51.52
16 years or above	48	48.48
School		
City	78	78.79
Rural	21	21.21
Union		
Member	74	74.75
Not member	25	25.25

Table 2. Distribution of school managers according to their indicative information

	Number (n)	Percentage (%)
Gender		
Female	12	48
Male	13	52
Age group		
45-49 years	7	28
50 years and above	18	62
Education Level		
Undergraduate	19	73,1
Graduate	7	26.9
Experience		
20 years or below	1	3.8
21 years or above	25	96.2

An examination of **Table 1** shows that 80.81% of the teachers who participated in the study were female and 19.19% were male, 26.26% were 39 years of age or under, 34.34% were between 40 and 45 years of age, 39.39% are were 46 years or older, 75.76% were nationals of Northern Cyprus only and 24.24% were nationals of both Northern Cyprus and Turkey. It can be seen that 81.82% of the teachers have undergraduate degree, 18.18% have graduated degrees, 51.52% had15 years of experience or less, whereas 48.48% have 16 or more years of experience in the profession. It was also found that 78.79% of the teachers who participated in the study worked in urban areas, whereas 21.21% worked at schools located in rural area. Finally, it can be seen 74.75% of teachers were members of a union.

Purposive sampling and convenience case sampling methods were used in the process of identifying the school managers who would participate in the study. Researchers made the effort to interview the managers of the schools that they visited in order to conduct the questionnaire study with teachers. Thus, the research gained speed, practicality and economy, and data were collected from the most accessible school manager group. Demographic information on the school managers who participated in the study is given in **Table 2**.

An examination of **Table 2** shows that 48% of the school managers who participated in the study were female and 52% were men, 28% were in the 45-49 age interval, and 62% are 50 years of age or older. It can also be seen that 73.1% of the school managers have undergraduate degrees and 26.9% have graduate degrees, 3.8% have 20 years or less professional experience and 96.2% have 20 years or more of professional experience. When the school managers were asked about their undergraduate field of study, it was found that nine graduated from social sciences, eight graduated from natural sciences, three graduated from foreign language, two graduated from art, one graduated from sports and one graduated from management.

DATA COLLECTION TOOLS

In order to generate the quantitative data of the study, a personal information form was used to obtain demographic information on the Turkish language and literature teachers. In this form, questions were asked on gender, age, nationality, level of education, experience, the location of the school and union membership.

A questionnaire was prepared by the researchers with the purpose of determining the technology usage status of teachers and the extent to which they believe that using technology is necessary. A literature review was conducted in order to ensure the scope validity of the questionnaire. Accordingly, reference was made to the articles authored by Güneyli and Özgür (2007) and Güneyli, Özgür and Zeki (2009) for the questions in the questionnaire titled "Professional Competencies of Turkish Language and Literature Teachers on the Basis of the Ability of Using and Managing Technology". Resultantly, a total of five questions were included in the questionnaire. Teachers were asked to choose the answer they felt to be appropriate from "very necessary", "necessary", "moderately necessary", "unnecessary" and "very unnecessary" from the options in the mentioned five questions. Once the draft questionnaire form was prepared, the opinions of three experts (computer and teaching technologies, measuring-evaluation and Turkish education) were obtained. After the expert opinions were received, a pilot study was conducted at a secondary education institution. The questionnaire was finalised after expert opinions were obtained and the pilot application was completed. Reliability and validity calculations were not needed because the analysis of each question in the questionnaire was performed independently and total scores were not calculated; however, the questionnaire was created taking into consideration the factors which affected reliability and validity.

A semi-structured interview form was prepared in order to determine the expectations of school managers from Turkish language and literature teachers and their professional competencies. This form was prepared by the researchers and consists of two sections. The first section consists of questions with short answers which aim to determine demographic information (gender, age, experience, undergraduate field of study, level of education). The second section of the interview form consists of open-ended questions. In order to avoid unnecessary question load on the interviewees, the number of questions was limited to five. These questions are mainly directed at exploring the expectations of school managers from Turkish language and literature teachers. In order to evaluate the validity, comprehensibility and fitness of the interview form in relation to the research problem, opinions were sought from three experts (the same experts whose opinions were sought in the questionnaire). Subsequently, a pilot application was performed with two managers and the questions were given their final version.

COLLECTION AND ANALYSIS OF DATA

In the study, an application was filed to the Academic Ethics Board at the researchers' university and a report was obtained which approved the ethical fitness of the measurement tools used. Later, permission was obtained from the Ministry of National Education in Northern Cyprus in terms of the applicability of the scale in secondary education institutions. After receiving ethical clearance and application permission, schools were visited, questionnaires were administered and interviews were conducted by researchers in person during school hours. Attention was paid to ensure participation was on a voluntary basis, and the teachers and school managers who did not want to participate in the study were not forced. The names of schools and participants were kept confidential by the researchers.

In order to be able to analyse quantitative data in the study, frequencies and percentages were used, which are descriptive statistics. Additionally, the chi-square test was applied in order to determine whether there were any differences in the answers given by teachers according to the independent variables. Separate chi-square tables were generated for each of the five questions and the findings were presented. Content analysis was conducted in order to analyse the qualitative data. The answers given by school managers were subjected to content analysis and codes were assigned; similar codes were grouped to form themes. The themes were classified to create categories. The frequency of preferring each category was stated as "frequency" and percentages were also included; in summary, qualitative data were digitalized and tabulated. In order to be able to view the themes and categories concretely, the opinions of school managers were directly included and citations were made. The names of school managers were kept confidential and codes were used (such as SP1 for school principal 1) in order to present the citations.

Table 3. Distribution of opinions of teachers in regard to the management and use of technology in education

	Necessary		Very Necessary	
	n	%	n	%
Being equipped with skills that a modern teacher should possess (computer, internet ...)	37	37.37	62	62.63
Effective, proper and accurate employment of teaching-learning strategies, methods, techniques and tactics in the learning-teaching environment	43	43.43	56	56.57
Ensuring student participation at intra-school multiple learning environments	50	50.51	49	49.49
Ensuring student participation at extra-school multiple learning environments	60	60.61	39	39.39
Directing students towards the use of diverse materials and resources	50	50.51	49	49.49

Table 4. Comparison of the answers given by teachers to the proposition "Being equipped with skills that a modern teacher should possess (computer, internet ...)" based on their introductory information

	Necessary		Very necessary		X^2	P
	n	%	n	%		
Gender						
Female	29	36.25	51	63.75	0.225	0,635
Male	8	42.11	11	57.89		
Age group						
39 years and below	10	38.46	16	61.54	0.096	0,953
40-45 years	12	35.29	22	64.71		
46 years and above	15	38.46	24	61.54		
Nationality						
North Cyprus	27	33.75	48	60.00	0.249	0,617
North Cyprus and Turkey	10	41.67	14	58.33		
Education Level						
Undergraduate	31	38.27	50	61.73	0.153	0,695
Graduate	6	33.33	12	66.67		
School						
City	29	37.18	49	62.82	3.922	0,141
Rural	8	38.10	13	61.90		
Union						
Member	30	40.54	44	59.46	0.006	0,939
Not member	7	28.00	18	72.00		

FINDINGS

The research first presents the quantitative findings in tables. Accordingly, an evaluation was made to determine whether there are any significant differences in the answers given by Turkish language and literature teachers to the five questions in the questionnaire according to their personal information. **Table 3** presents the distribution of answers "very necessary" and "necessary" in regard to these questions.

An examination of **Table 3** shows that 37.37% of the teachers who participated in the study answered "necessary" to the proposition "Being equipped with skills that a modern teacher should possess (computer, internet …)" while 62.63% answered "very necessary". Furthermore, 43.43% of the teachers answered "necessary" to the proposition "Effective, proper and accurate employment of teaching-learning strategy, method, technique and tactics in learning-teaching environment", whereas 56.57% answered "very necessary". A total of 50.51% of teachers answered "necessary" to the proposition "ensuring participation of all students at intra-school multiple learning environments (seminars, conferences, panels etc…) with the teacher and other students which develop their learning-focused interaction and organizing such learning environments", whereas 49.49% answered "very necessary". It can be seen that 60.61% of the teachers answered "necessary" to the proposition "ensuring participation of all students at extra-school multiple learning environments (seminars, conferences, panels etc…) with the teacher and other students which develop their learning-focused interaction and organizing such learning environments", whereas 39.39% answered "very necessary". Finally, 50.51% of teachers answered "necessary" to the proposition "Directing students towards the use of diverse materials and resources", while 49.49% answered "very necessary".

Table 5. Comparison of the answers given by teachers to the proposition "Effective, proper and accurate employment of teaching-learning strategies, methods, techniques and tactics in the learning-teaching environment" based on their introductory information

	Necessary		Very necessary		X^2	P
	n	%	n	%		
Gender						
Female	33	41.25	47	58.75	0.810	0.368
Male	10	52.63	9	47.37		
Age group						
39 years and below	12	46.15	14	53.85	0.570	0.752
40-45 years	13	38.24	21	61.76		
46 years and above	18	46.15	21	53.85		
Nationality						
North Cyprus	34	42.50	41	51.25	0.454	0.500
North Cyprus and Turkey	9	37.50	15	62.50		
Education Level						
Undergraduate	38	46.91	43	53.09	2.195	0.138
Graduate	5	27.78	13	72.22		
School						
City	34	43.59	44	56.41	0.410	0.815
Rural	9	42.86	12	57.14		
Union						
Member	30	40.54	44	59.46	0.004	0.952
Not member	13	52.00	12	48.00		

Table 6. Comparison of the answers given by teachers to the proposition "ensuring participation of all students in intra-school multiple learning environments (seminars, conferences, panels etc…) with the teacher and other students which develop their learning-focused interaction and organizing such learning environments" based on their introductory information

	Necessary		Very necessary		X^2	P
	n	%	n	%		
Gender						
Female	40	50.00	40	50.00	0.043	0.837
Male	10	52.63	9	47.37		
Age group						
39 years and below	13	50.00	13	50.00	0.338	0.844
40-45 years	16	47.06	18	52.94		
46 years and above	21	53.85	18	46.15		
Nationality						
North Cyprus	35	43.75	40	50.00	1.823	0.177
North Cyprus and Turkey	15	62.50	9	37.50		
Education Level						
Undergraduate	39	48.15	42	51.85	0.990	0.320
Graduate	11	61.11	7	38.89		
School						
City	38	48.72	40	51.28	2.265	0.322
Rural	12	57.14	9	42.86		
Union						
Member	38	51.35	36	48.65	0.470	0.493
Not member	12	48.00	13	52.00		

When the chi-square analysis results given in **Table 4** are examined, it is found that there is no statistically significant difference between the answers given by teachers who participated in the research to the proposition "Being equipped with skills that a modern teacher should possess (computer, internet …)" according to their introductory characteristics ($p>0.05$). The opinions of teachers in regard to preparedness are found to be similar according to their introductory characteristics.

According to the data in **Table 5**, it has been found that there is no statistically significant difference between the answers given by teachers included in the research to the proposition "Effective, proper and accurate employment of teaching-learning strategies, methods, techniques and tactics in the learning-teaching environment" according to their introductory characteristics ($p>0.05$).

Table 7. Comparison of the answers given by teachers to the proposition "ensuring participation of all students at extra-school multiple learning environments (seminars, conferences, panels etc...) with the teacher and other students which develop their learning-focused interaction and organizing such learning environments" based on their introductory information

	Necessary		Very necessary		X^2	P
	n	%	n	%		
Gender						
Female	48	60.00	32	40.00	0.064	0.800
Male	12	63.16	7	36.84		
Age group						
39 years and below	14	53.85	12	46.15	2.030	0.362
40-45 years	19	55.88	15	44.12		
46 years and above	27	69.23	12	30.77		
Nationality						
North Cyprus	44	55.00	31	38.75	0.487	0.485
North Cyprus and Turkey	16	66.67	8	33.33		
Education Level						
Undergraduate	47	58.02	34	41.98	1.243	0.265
Graduate	13	72.22	5	27.78		
School						
City	45	57.69	33	42.31	3.009	0.222
Rural	15	71.43	6	28.57		
Union						
Member	12	48.00	13	52.00	1.308	0.253
Not member	47	63.51	27	36.49		

Table 8. Comparison of the answers given by teachers to the proposition "Directing students towards the use of diverse materials and resources" based on their introductory information

	Necessary		Very necessary		X^2	P
	n	%	n	%		
Gender						
Female	41	51.25	39	48.75	0.093	0.761
Male	9	47.37	10	52.63		
Age group						
39 years and below	11	42.31	15	57.69	1.690	0.430
40-45 years	20	58.82	14	41.18		
46 years and above	19	48.72	20	51.28		
Nationality						
North Cyprus	36	45.00	39	48.75	0.777	0.378
North Cyprus and Turkey	14	58.33	10	41.67		
Education Level						
Undergraduate	41	50.62	40	49.38	0.002	0.962
Graduate	9	50.00	9	50.00		
School						
City	39	50.00	39	50.00	2.265	0.322
Rural	11	52.38	10	47.62		
Union						
Member	40	54.05	34	45.95	0.038	0.846
Not member	10	40.00	15	60.00		

According to **Table 6**, it has been found that there is no statistically significant difference between the answers given by teachers included in the research to the proposition "ensuring participation of all students at intra-school multiple learning environments (seminars, conferences, panels etc…) with the teacher and other students which develop their learning-focused interaction and organizing such learning environments" according to their introductory characteristics ($p>0.05$).

According to **Table 7**, it has been found that there is no statistically significant difference between the answers given by teachers included in the research to the proposition "ensuring participation of all students at extra-school multiple learning environments (seminars, conferences, panels etc…) with the teacher and other students which develop their learning-focused interaction and organizing such learning environments" according to their introductory characteristics ($p>0.05$).

Table 9. Expectations of school managers from Turkish language and literature teachers and their opinions concerning technology usage and management abilities

MAIN THEME	THEME	N	%
Raising students who have the knowledge, skills and affective acquisitions targeted in language and literature education	*Student with developed language skills (N=15)* *Student who loves language and literature (N=7)* *Student who has a good command of grammar rules (N=4)* *Student who learned the topic-content in the curriculum (N=2)* *Student with rich vocabulary (N=1)*	**29**	**43.28**
Possessing the professional and personal competencies required as a Turkish language-literature teacher	*Teacher who is a role model for his/her students in language-literature knowledge, accumulation and awareness (N=7)* *Teacher who has good communication with his/her students, who guides and helps them (N=3)* *Teacher who innovates and improves himself (N=2)* *Teacher with teamwork skills (N=2)* *Teacher with work discipline (N=2)* *Teacher who is successful at class management (N=1)*	**17**	**25.37**
Raising language and literature students who are sensitive towards their country, the people around them, culture and art	*Transforming language-literature education into art education (N=4)* *Raising caring and considerate students (N=3)* *Raising students who love and appreciate their country (N=2)* *Raising students who are active in cultural activities (N=2)*	**11**	**16.42**
Realising technology-assisted and student-oriented language and literature education	*Performing student-centred education (N=2)* *Performing extra-class activities (N=1)* *Utilizing technology in classes (N=1)* *Making classes more enjoyable (N=1)*	**5**	**7.46**
Raising language and literature students who have high-level thinking skills	*Student with creativity (N=2)* *Student with research skills (N=1)* *Student with discussion-interpretation power (N=1)* *Student with effective communication skills (N=1)*	**5**	**7.46**
	Total	**67**	**100**

When the chi-square results given in **Table 8** are examined, it is found that that there is no statistically significant difference between the answers given by teachers to the proposition "Directing students towards the use of diverse materials and resources" according to their introductory characteristics ($p>0.05$).

The qualitative findings of the study are presented in **Table 8**. The expectations of school managers who participated in the study from Turkish language and literature teachers and particularly their opinions on the abilities of teachers in using and managing technology are evaluated and tabulated.

When the opinions of school managers given in **Table 9** are evaluated, it can be seen that the emphasis is particularly on raising qualified students. Emphasis was placed on the necessity of having curricula which equip students with cognitive and emotional. acquisitions (43.28%), sensitiveness towards their culture, environment and art (16.42%) and high-level thinking abilities (7.46%). On the other hand, the qualifications of teachers were also emphasised by school managers (25.37%). School managers claimed that language and literature teachers have to be qualified in personal and professional terms. Finally, it was identified that technology-assisted and student-oriented language and literature education should be delivered (7.46%), which is the fundamental topic of this study.

The opinions of school managers in regard to "Raising students who have the knowledge, skills and affective acquisitions targeted in language and literature education" are as follows:

> *"I expect that they improve the speaking language of their students, encourage then to read, and raise students who can interpret, write and convey their ideas to others"* SP 23 (Student with developed language skills)

> *"I would expect that the teacher particularly focuses on using Turkish language accurately and effectively, has a passion for literature, and makes students understand that life itself is literature"* SP 14 (Student with love of language-literature)

> *"He must teach students how to use Turkish accurately"* SP 20 (Student with good command of grammar rules)

> *"I would expect that teachers know how to share knowledge and make the effort to help their students."* SP 26 (Topic in the programme-student who learned the content)

> *"I expect that teachers will teach their students how they can use Turkish words. I expect that they encourage students to use Turkish words instead of foreign words."* SP 7 (Student with rich vocabulary)

The opinions of school managers in regard to "Possessing the professional and personal competencies required as a Turkish language-literature teacher" are as follows:

> *"I expect that teachers will be good readers themselves so that they can instil the love of reading in their students."* SP 9 (Teacher who is a role model for his/her students in language-literature knowledge, accumulation and awareness)

> *"I expect them to be patient and guiding when they are delivering the Turkish language and literature course to the new generation of students"* SP 19 (Teacher who has good communication with his/her students, who guides and helps them)

> *"I expect them to be readers and researchers, and love literature and humans."* SP 17 (Teacher who innovates and improves himself)

> *"First of all, I expect them to work in harmony, organize activities at school with other teachers and cooperate with their colleagues."* SP 25 (Teacher with teamwork skills)

> *"I expect them to deliver their classes regularly, come to school and not use casual leave*." SP 17 (Teacher with work discipline)

> *"First of all, I expect them to create a caring and considerate classroom environment. I prefer them not to have any problems, especially in classroom management*." SP 16 (Teacher who is successful at class management)

The opinions of school managers in regard to the "Raising language and literature students who are sensitive towards their country, those around them, culture and art" main theme are as follows:

> *"Turkish language and literature teachers are the focal point of the cultural life of the school. In the classroom, they have to be a master and a drama artist. Imposing love for reading, going to theatre, and listening to poems are in the hands of teachers…"* SP 15 (Transforming language-literature education into art education)

> *"Teachers must bring the humanist feelings of students to the fore with the activities that they would perform."* SP 15 (Raising considerate students)

> *"They should raise students who are leaders in cultural activities and love their language, country and people."* SP 6 (Raising students who love and appreciate their country; raising students who are active in cultural activities)

The opinions of school managers as regards "Realising technology-assisted and student-oriented language and literature education" main theme are as follows:

> *"They should be teachers who are student-oriented, avoid rote learning and educate their students based on the realities of modern society."* SP 21 (Performing student-centred education)

> *"Teachers have to be active in extra-class activities and share with their students."* SP 16 (Performing extra-class activities)

> *"Turkish language and literature teachers must be versatile. They must make the effort to make the class enjoyable and interesting and should be able to use all kinds of technologies in their classes."* SP 11 (Utilizing technology in classes; making classes more enjoyable)

The opinions of school managers in regard to the "Raising language and literature students who have high-level thinking skills" main theme are as follows:

> *"I expect that they ensure that students understand the importance of reading so as to express themselves better and display concrete products by utilizing their creativity and imagination."* SP 7 (improving the creativity of students)

> *"They must be teachers who impart the love for reading and researching to our children. For example, they must raise students who are able to compare world literature and Turkish literature."* SP 21 (Raising students with research skills)

> *"I expect that they raise students who read and discuss, interpret and convey to others what they read."* SP 23 (Student with discussion-interpretation power)

> *"I would prefer to raise students who are strong in literature and communication."* SP 25 (Raising students with effective communication skills)

In conclusion, the qualitative and quantitative findings of the study are given above. In this context, the technology usage and management skills of teachers were evaluated on the basis of their opinions and the views of school managers within the framework of the professional qualifications of Turkish language and literature teachers. The interpretations of researchers in regard to the findings are presented below in association with the literature (conclusion and discussion).

CONCLUSION, DISCUSSION AND RECOMMENDATIONS

The conclusions of the study can be summarised as follows:

- The language and literature teachers who participated in the study have the opinion that using technology in education is necessary and even very necessary.
- Significant differences were not observed according to the demographic characteristics of the teachers who participated in the study (age, experience, gender etc.) in regard to the necessity of using technology in education.
- The expectations of school managers from language and literature teachers were evaluated and only a limited number of managers (only 1 student out of 26) emphasised that teachers should be competent in using technology.

When the research findings are discussed, the following can be claimed: in a course such as language and literature where communication, interaction and various skills are at the forefront, it is essential that teachers create a learning environment with multiple stimulants (Göçer, 2010; Hayran, 2010; Turhan, 2016). Thus, in this study, teachers answered "necessary" and "very necessary" to the questions related to the use of technology in education. With a constructivist learning approach, teaching methods which ensure that students are actively involved in the learning process have replaced the teaching methods that give students a passive role (Alvarez, 2012; Guo, 2011). Thus, using methods and techniques which result in high-level thinking such as criticism, interpretation, analysis and synthesis in Turkish classes play an essential role in the realisation of the course objectives (Aslan, 2010). Some measures which can increase effectiveness must be taken into consideration while performing activities based on the constructivist approach. For example, the constructivist approach does not approve of Turkish teachers only covering the topics in the coursebook without paying any attention to the interests and needs of students. Whereas written instruments-tools were preferred in Turkish teaching in the past, today, as a result of technological developments, instruments such as pictures, film strips, projectors, radio-television, and computers-internet are being used. In constructivism, it is envisaged that these materials are not only used by teachers in the classroom; instead, they should also be used by students and planning should be made cooperatively (Arslan, 2009).

In his study, Çakır (2009) interviewed 35 Turkish language and literature teachers and determined that only one Turkish language and literature teacher used technology in the classroom. In the same study, only 2.8% of the opinions given by teachers indicated that technology usage is applied in the classroom to make students active and to encourage them to think. Additionally, teachers presented the problems they experienced while using methods and techniques based on constructivism; however, they did not think that the lack of computers and the Internet would be a problem for students (1.7%). In regard to how constructivist methods and techniques could be used more intensely in classrooms, a limited number of teachers (10.6%) stated that "technological means in the classroom should be improved".

In his study, Arslan (2008) found that teaching technologies and materials are not adequately used in Turkish classes and behaviours suitable for constructivist process are only partially displayed. In Karadüz's research (2010), it was concluded that teachers continued to apply the behaviourist approach from many perspectives in the learning environments of Turkish classes and did not give any consideration to constructivism. In the study conducted by Arslan, Orhan and Kırbaş (2010), school managers stated that the constructivist learning approach was only partially applied in Turkish classes and that Turkish language teachers only partially performed the roles ascribed to them by the constructivist approach. Based on the findings of this study, it is evident that although teachers indicated that using technology is highly necessary, they still could not realise the required transformation in their classrooms or courses and that they could not deliver technology-assisted language and literature courses. Teachers may be inclined to perceive technology as a risky and potentially problematic instrument and disregard the benefits of technology so as not to harm their students. For example, the study conducted by Yaman and Erdoğan (2007) concluded that communication technologies in Turkish teaching weakened the writing and composition skills of students, that language was used haphazardly and carelessly, abbreviations and speaking language elements were used in spelling, and Turkish language was degenerated in terms of "phonetic", "syntax" and "spelling". These are the reasons why a teacher who experiences these problems refrains from using computers in his/her classes. Attempts should therefore be made to solve these problems and use technology effectively in the teaching-learning process.

The following conclusions can be made based on the qualitative data of the study. According to the results of this study, school managers do not expect language and literature teachers to be competent in technology. This is due to the fact that school managers themselves are not competent or interested in technology; thus, it could be the case that school managers do not expect teachers to be competent in technology as they themselves are not highly competent. However, studies conducted on technology leadership show that school managers should follow innovative technological developments and take the lead in their application in order to be defined as a "technology leader" (Çakır, 2013; di Benedetto, 2006, Gökoğlu, 2014). Thus, school managers should lead teachers first so that teachers can manage and use technology. School managers have to possess technological skills, ensure that technology is effectively used in schools and should be able to integrate technology with other managerial areas. According to Banoğlu (2011), a school manager who is a technology leader is also an effective education and teaching leader who facilitates the integration of education with technology, efficiently uses existing school resources in order to acquire education and management technologies and creates additional resources when necessary, closely monitors the command of teachers in education technology and their professionals development in that field, monitors and evaluates in technological media the teaching activities and student achievements at their school, and gives sufficient consideration to the technological means of communication in school-environment interaction.

Based on the findings of the study, the following recommendations are offered:

- Teachers must accept the reality that even though they agree that technology is necessary, this opinion in fact has no value as technology is still not used.
- Even the level of education, in other words having a graduate degree or the age of the teacher (being a recent graduate) do not make any significant difference in terms of technology usage. Thus, awareness should be given on technology-assisted education during graduate education. Updating teacher education programmes is also essential, as even recently graduated teachers lack the required professional competencies for using technology.

In-service training of school managers is also very essential. It is the management philosophy of teachers which determines whether all teachers in a given school improve themselves in the field of technology and are inclined towards using technology. In this context, education policies should be formed which envisage that on-the-job training activities begin with school managers and that every school manager becomes a technology leader.

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