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The Effects of Concept Map-Oriented Gesture-Based Teaching System on Learners' Learning Performance and Cognitive Load in Earth Science Course

Sheng-Wen Hsieh
Far East University, TAIWAN R.O.C.
Shu-Chun Ho
National Kaohsiung Normal University, TAIWAN R.O.C.
Min-ping Wu
Far East University, TAIWAN R.O.C.
Ci-Yuan Ni
National Kaohsiung Normal University, TAIWAN R.O.C.

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Gesture-based learning have particularities, because learners interact in the learning process through the actual way, just like they interact in the nondigital world. It also can support kinesthetic pedagogical practices to benefit learners with strong bodily-kinesthetic intelligence. But without proper assistance or guidance, learners' learning performance are usually disappointing. To cope with this problem, the aim of this paper proposed a concept map-oriented gesture-based teaching system in earth science course. There were 90 participants in the experiments designed with the three teaching strategies (concept map-oriented gesture-based teaching system, conventional gesture-based teaching system, and traditional e-book teaching materials). The experimental results show that the concept map-oriented gesture-based teaching strategy and traditional e-book teaching materials also improve the learning performance of the students in earth science course than conventional gesture-based teaching strategy. Learners' cognitive load was also measured and showed that the concept map-oriented gesture-based teaching strategy had lower cognitive load than conventional gesture-based teaching strategy. There was no significant difference in learning performance and cognitive load between the concept map-oriented gesture-based teaching strategy and traditional e-book teaching materials.

Keywords: gesture-based learning, concept maps, cognitive load, earth science course

Correspondence: Sheng-Wen Hsieh,
Department of Management Information Systems, Far East University, No.49, Zhonghua Rd., Xinshi Dist., Tainan City 74448, Taiwan (R.O.C.)
E-mail: onyx@cc.feu.edu.tw
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INTRODUCTION

The first category belongs to the parts of graphical user interfaces (GUI), especially mouse-based and keyboard-based interfaces. It is designed with a graphical user interface for computer operation (Jaimesa & Sebe, 2007). The second one belongs to the parts of natural user interfaces (NUI) with voice-based and gesture-based user interfaces operable. It is unnecessary for users to equip themselves with relevant prior knowledge, but allowable for the intuitive interaction between users and computers. Currently, NUI has been widely applied to numerous professional fields including some aspects like medicine, entertainment and education (Kean, Hall & Perry, 2011). For example, Richard et al. (2011) adopted a NUI sensor to construct an accurate real-time imaging system against complex interior space. Weise et al. (2011) further captured and tracked the real-time dynamic facial expressions of users and sketched digital roles. Due to the continuous development of aforesaid emerging kinetic technologies, at present, it is an important issue with novel technologies introduced into learning applications. However, it is still required to combine relevant educational theories or strategies with effective assistance available for learners to enhance learning performance and quality. However, currently, NUI experiments and development are still under the initial stage. Numerous scholars emphasize the technological innovation with NUI sensors applicable to educational aids. Still, it lacks appropriate strategies or tools with learning aids available for learners. Therefore, aside from the consideration of kinetic technologies, in this research, educational strategies are also taken into consideration.

State of the literature

- NUI experiments and development are still under the initial stage. Numerous scholars emphasize the technological innovation with NUI sensors applicable to educational aids. Still, it lacks appropriate strategies or tools with learning aids available for learners.
- The learning process allowable for learners to conduct learning activities through meaningful bodily involvement in a kinetic way with cognitive construction of scientific knowledge constructed in the brain will be the most and intuitive way to complete the convenience and learning of scientific knowledge.

Contribution of this paper to the literature

- This paper adopts kinetic technologies served as a supportive role for learning activities to develop a set of kinetic teaching system combined with concept maps. Also, the influential factors on learning achievements and cognitive load of learners are taken into consideration to explore effectiveness and practicality in teaching activities.
- The experimental results show that the concept map-oriented gesture-based teaching strategy and traditional e-book teaching materials also improve the learning performance of the students in earth science course than conventional gesture-based teaching strategy.

For some learning contents of abstract concepts like natural science or mathematics, if there is no support or aids available for learning activities, children will lose their interest in reading (Mantzicopoulos & Patrick, 2010). Researchers also indicate except the occasions available to propose effective learning strategies or tools, the learning achievements of students will bring with disappearing results finally (Chen et al., 2009; Chu, Hwang & Tseng, 2010; Liu et al., 2009). Because traditional teaching activities of Earth Science are often confined by teaching fields, numerous abstract concepts cannot be conveyed to learners in a definite way. In view of the development of emerging kinetic technologies, together with the interactively functional features available to make breakthrough in the conveyance of abstract concepts through the traditional fields of classrooms, among them, concept maps means a strategy helpful for learners to understand conceptual relationship and organize information through visualized graphics. Among numerous concept maps ways recently developed, the mostly applied one is exactly the concept maps strategy of node linkage (Novak & Gowin, 1984). With qualitative and quantitative researching verification, it is available for researches to confirm a fact concept maps can effectively facilitate meaningful learning activities with positive influence on students resultantly (Liu et al., 2005). For the past several years, numerous professional applications of concept maps also play different roles inclusive of constructing knowledge and organizing tools (Erdogan, 2009), measurement tools of knowledge structure (Chang et al., 2005) and guidance tools of learning (Panjaburee et al., 2010). Consequently, concept maps can be served as a visualized cognitive tool facilitating students to organize their own knowledge and learning experience and also enhance their self-consciousness through reflection (Kao, Lin & Sun, 2008a, 2008b).

In cognitive concepts, Churchland (1989) contends the brain is a machine functioned with parallel cooperative activities. Therefore, aside from simple cognition, the brain can also deal with other limb activities meanwhile. In recent years, the development of cognitive science has gradually started to emphasize the correlation between cognition and limb motions. Also, neuroscience confirms mentality is closely correlated to limb motions. In addition, Rambusch and Ziemke (2005) contends, mentality and limb motions cannot be separated for decoding. In view of the opinions of embodied cognition, bodily involvement plays a core part in the process of cognitive formation mainly because bodily involvement is helpful for cognitive development (Barsalou, 2008). Thus, the cognition of an individual is no more a simple concept of a brain structure merely, but it is affected by the system of multiple modules like limb motions, simulation and settings to result in cognitive formation. If learners lack the capabilities to understand abstract concepts, it is required for concrete objects facilitating learning activities (Piaget, 1974; Inhelder & Piaget, 1958). The learning process allowable for learners to conduct learning activities through meaningful bodily involvement in a kinetic way with cognitive construction of scientific knowledge constructed in the brain will be the most and intuitive way to complete the convenience and learning of scientific knowledge.

The development of teaching tools has reached its maturity and it is technically easy to establish a teaching system. Currently applicable electronic teaching activities embrace mobile learning, ubiquitous learning and E-book learning wherein most electronic teaching activities adopt E-books. However, whether teaching systems can be effectively helpful for learners to correct the errors of past teaching ways with learning achievements and teaching quality well improved is exactly the very issue and challenge faced by teaching systems. Resultantly, excellent teaching systems should be based on educational theories to combine information technologies and teaching strategies with learning achievements enhanced (Hwang, Wu & Chen, 2007). Therefore, aside from using the emerging kinetic technologies served as the core techniques for teaching systems, this research also adopts the courses of Earth Science served as teaching goals helpful for learning concepts. Additionally, with the teaching strategies of concept maps to serve as an aiding role, it is effectively helpful for students to organize their knowledge and learning experience. As such, it aims to explore the combination of teaching activities with the teaching strategies of conceptual mapping, non-concept maps and traditional E-books. It is expected the ultimate goals for the enhancement of learning motives, learning interest and meaningful learning will be reachable.

LITERATURE REVIEW

Kinetic technologies

The bodily interaction driven by kinetic technologies can be viewed as an innovative educational development. It is available for interactive operation by using gestures and bodily motions (Johnson et al., 2010). The settings of multimedia learning activities provide students with a more convenient and intuitive way to conduct interactive activities in view of teaching contents. Due to the rapid development of relevant kinetic technologies, various kinds of techniques have been widely proposed and discussed. For example, the Motion Plus, a WiFi handheld kinetic controller proposed by Nintendo is functioned with gesture detection through acceleration calculators and infrared transmission devices. The Play Station 3 proposed by SONY is functioned with gesture detection by using a kinetic motion controller. The Kinetic device proposed by Microsoft is a motion sensor devised with a camera, a 3D depth camera and an array microphone. It is functioned to detect the motions of bodily skeletons and voice through an infrared transmitter with the interactive effect of limb motions and the system reachable. It is allowable for users to directly control, operate and interact through gestures and voice commands unnecessary to touch any other controllers (Dutta, 2012). Kinect is mainly featured with a novel revolutionary way available for gaming interaction. It is not only a milestone but also a focus receiving the attention from numerous researchers and product developers in different fields.

Currently, kinetic technologies are not only the sensor devices available for consumers, but also the applications widely prevalent in numerous professional fields including medicine, entertainment, marketing and robots. For example, Gordon and Okita (2010) uses the Wii proposed by Nintendo for Pediatric motion-induced therapies and contends video games and virtual reality will definitely become the important parts for rehabilitation in the future. Tong et al. (2012) uses Kinect to conduct 3D human-body scanning with experimental results indicating the effectiveness and practicality of human-body identification and tracking for this system. Chiang, Tsai and Chen (2012) uses Kinect to find the benefit for both the health and vision of seniors caused by kinetic video games. Clark et al. (2012) uses Kinect to determine and evaluate the balance controllability of stationary standing stances for humane motional appraisals. Qian et al. (2013) uses Kinect to develop a gesture-based remote human-computer interaction system functioned with remote gesture controllability to verify the effectiveness and practicality of the proposed system. Southwell and Fang (2013) uses Kinect to collect the information of different colors and depths to identify the goals of human bodies and track the identification capabilities of both stationary and moving status of different human bodies. Galatas, Ferdous and Makedon (2013) uses Kinect to conduct the positioning of human bodies and the detection of emergency events. Therefore, Kinect has provided a reliable identification way to track human bodies. It can effectively identify numerous graphics, colors, gestures and bodily motions driven by different objects and goals.

In this research, with further insightful effort, it is found kinetic technologies allow users to conduct interactive communication with the system in a most naturally intuitive way. Also, because of this situation, inconvenient or disable users can correctly and effectively use this system with the aiding function available. Additionally, kinetic technologies can, indeed, effectively enhance the attentive focus, interest and immerging power of learners on the courses studied with learning achievements well improved. Past researches sufficiently exert the interactively powerful functions of human-computer interfaces driven by kinetic technologies (Grieser et al, 2012; Chang et al, 2013; Hwang, Wu & Ke, 2013; Huang et al, 2012; Galatas, Ferdous & Makedon, 2013; Lee et al, 2011; Mentiplay et al, 2013; Qian, Niu & Yang, 2013; Vernadakis et al, 2012; Wachs et al, 2011). It is supportive for the materialization of kinetic teaching methods and instrumental in promoting bodily kinesthetic intelligence. Hsu (2011) indicates the interaction of limb motions and gestures driven by Kinect can inspire educational workers to focus on the materialization of kinetic teaching strategies in classrooms. It cannot only provide an innovatively interactive way, but also receive more attention from researchers and product developers in relevant professional fields. However, it is still under the initial R&D stage lacking appropriate strategies or tools to facilitate learning activities. Therefore, aside from the consideration of kinetic technologies, this research also takes teacher strategies into consideration with more insightful exploration focusing on the influence on learning performance and the creation of cognitive load when kinetic technologies are combined with teaching strategies. From relevant applications of kinetic technologies, in this research, it is found the functions of kinetic technologies are better fitting to the characteristics of the learning environment and the design concepts of kinetic teaching systems for this research.

Concept maps

Concept maps can be served as a teaching tool to express the structure of conceptual knowledge. Through the conceptual structure of an individual, it aims to facilitate the improvement for the design of teaching activities in teachers and the learning performance of students (Novak & Gowin, 1984; Novak & Musonds, 1991). Concept maps mean a kind of teaching way to construct knowledge widely receiving attention from everywhere. Furthermore, in the process of the learning activities of students, it exerts positive influence on qualitative and quantitative researches (Horton et al., 1993; Trent et al., 1998). The teaching way of concept maps is meant to express the “concepts” and “relationship” of cognitive structure in a visualized way. In the mapping process, it is required for learners to implement hierarchical categorizing and grouping arrangement for learning contents with every concept served as a single node wherein 2 different concepts are linearly linked together with a conjunction marketing the conceptual relationship, namely a preposition. As such, concepts are incessantly linked together to form a network structure finally, namely concept maps (Novak & Gowin, 1984). In the hierarchical relationship of concept maps, main or generic concepts are placed onto the highest level and then followed by the lower levels of generic or specific concepts. Concrete examples are placed in the lowest level.

The construction of concept maps is divided into 2 different ways wherein one is established by learners and the other category of concept maps is established by experts. The establishment of concept maps made by learners is congruent with the idea of constructivism. The process when learners are constructing concept maps is helpful for learners to confirm important concepts and delineate conceptual relationship and knowledge structure (Boyle & Weishaar, 1997; McCagg & Dansereau, 1991). Teachers provide experts with the ways to construct concept maps and this is another teaching way. When Liu et al. (2010) conducts a research with the concept maps of computers helpful for learners’ English reading comprehension, research results indicate tabulation, enforcement and review are exactly the most effective learning strategies in English reading comprehension. Such concept maps can allow students with a scaffolding function to facilitate the learning achievements of proximal development zone among students (Novak & Cañas, 2006). Resultantly, it can enhance learners’ capabilities of English reading comprehension with excellent learning achievements reachable. Therefore, the aids with a scaffolding function can help learners complete and even transcend the learning tasks within the capabilities of learners (Wood, Bruner & Ross, 1976). Because concept maps can motivate learners to reflect, organize and reform knowledge structure. Therefore, they are oftentimes used to support various types of teaching activities (Roth & Roychoudhury, 1994). Furthermore, concept maps are also combined with the representation of knowledge, the construction of learning and meaningful learning activities wherein researches also indicate excellent effectiveness in learning activities (Chang et al., 2005).

Concept maps mean a kind of visualized cognitive tool supportable by using computer software (Anderson-Inman & Ditson, 1999; Fischer et al., 2002). Meanwhile, it is also a kind of effective cooperative learning tool with meaningful learning available through sharing (Novak & Gowin, 1984; Okebukola & Jegede, 1988; Roth & Roychoudhury, 1994). In the past, concept maps were applicable to numerous different fields. However, through the innovative improvement of technologies, new applications of concept maps are proposed with better learning achievements available (Novak & Cañas, 2006). In the past, there had been numerous researches helpful for learning activities by effectively using concept maps or making breakthrough the geographical confinement through Internet among learners for collaborative concept maps on different sites (Chiu, Huang & Chang, 2000). Kwon and Cifuentes (2009) proposes when students are conducting collaborative concept maps for learning activities, it is more helpful for thinking made by an individual. Additionally, Kao, Lin & Sun (2008a; 2008b) uses concept maps to conduct mutually peering appraisals and reflective activities based on peering concept maps.

Aside from the learning activities among students, concept maps are also often combined with other theories for practical applications. Chen (2009) develops the Internet learning system for adaptive development through concept maps. Hughes and Hay (2001) uses concept maps to help the designers of teaching materials and develop excellent teaching materials available for learning activities. Furthermore, in this research, kinetic technologies are combined with the teaching strategies of concept maps to develop a set of kinetic teaching system integrated with concept maps. Also, it aims to explore the influential relationship between learning achievements and cognitive load among learners under different teaching strategies.

Cognitive Load Theory

Currently, the cognitive load theory is one of very important theories in the design of teaching activities. Sweller (1988; 1989) contends load means the loading volume with a special task imposed on the cognitive system of learning activities. Paas (1992) suggests cognitive load means a kind of concept of multiple dimensions. The concepts having multiple dimensions contain mental load and mental effort. When the higher difficulty or more mental effort an individual perceives learning contents, the heavier cognitive load it will be.

Paas and van Merriënboer (1993) contends cognitive load means a kind of concepts with multiple dimensions in mental sensation when an individual is dealing with his own tasks wherein the resources of influence are multiple including the factors of individual characteristics, tasks and external environment or the interaction between two different factors probably resulting in cognitive load. Cognitive load can be measured mainly by using two different dimensions inclusive of mental load and mental effort. Mental load means the load burdened by an individual in response to the demands of tasks or environment. Mental effort means the load spent by an individual to make tasks well completed (Paas & van Merriënboer, 1994).

The measurement of cognitive load increases the value applicable to teaching sites. It is available to understand the degrees of difficulty for an individual to deal with new messages aiming to make progress for the design of teaching activities. The measurement of cognitive load is mainly conducted through 2 different dimensions of tasks and learners (Sweller, van Merriënboer & Paas, 1998). The former is meant to measure the load volume in response to tasking demands for an individual. It is known as mental load mainly relevant to both internal (complexity or difficulty and easiness) and external (such as the demonstrating ways of the design of teaching materials). The latter is meant to measure the cognitive load spent by an individual in response to tasking demands, known as mental effort.

As Paas, Renkle and Sweller (2003) summarizes the measurement ways proposed in the period from 1988 to 2002, it is found after 1997, the measurement ways are mainly based on 7-point or 9-point "subjective scales". The cognitive load mentioned in this research is made by referring to the subjective scale proposed by Sweller, van Merriënboer and Paas (1998) with totally questions dealing with 2 aspects of metal load and mental effort separately. With the self-reflection made by learners, the sensation of learners themselves are quantitatively converted into load volume and this method shows better validity and reliability than those of physical scales, also resulting in higher practicability and feasibility.

METHODOLOGY

Experiment Design

In the learning process, learners can interact with practical settings through divergent teaching materials. Compared with traditional paper forms in teaching activities, it can trigger far more interest and motivation. To understand the influence on learning achievements and cognitive load caused by different teaching strategies imposed on learners, this research develops and designs a set of Kinetic Teaching System Integrated with Concept Maps (KTSICM). Also, the courses of 8 major planets in Earth Science are served as learning goals.

The kinetic teaching system integrated with concept maps is mainly composed of some prompting mechanisms of speech recognition, gesture recognition, real-time tests and concept maps. Thereafter, learners can conduct the learning activities on the courses of 8 major planets in Earth Science through gesture recognition and speech recognition in kinetic way. Through the sensing camera of different colors and depths, an matrix microphone and auxiliary induction-driven motors, the Kinect sensor can allow students with operable learning opportunities through kinetic interaction. However, when learners conduct learning activities, if misjudgment is caused by comprehensive loss or confusion, then this system provides the prompting mechanisms and the learning contents relevant to 8 major planets of Earth Science in response to the learning contents misjudged by learners. It is available for renewal reflection and the clarification of misjudged ideas made by learners. The overall system is composed of 10 learning tasks. Below description focuses on the first task to test the learning achievements of the courses about 8 major planets in the kinetic teaching system with the introduction available for real settings.

Task 1 is meant for the learning task to know about the relative positions of 8 major planets in the solar system, as shown in Figure 1. Therefore, when this kinetic teaching system is activated, learners can select one of 8 major planets by means of gesture recognition and speech recognition. After learners select one of 8 major planets based on their own internal knowledge structure, in a kinetic interaction way, the selected object is placed onto a correct position as learners suppose concurrently.

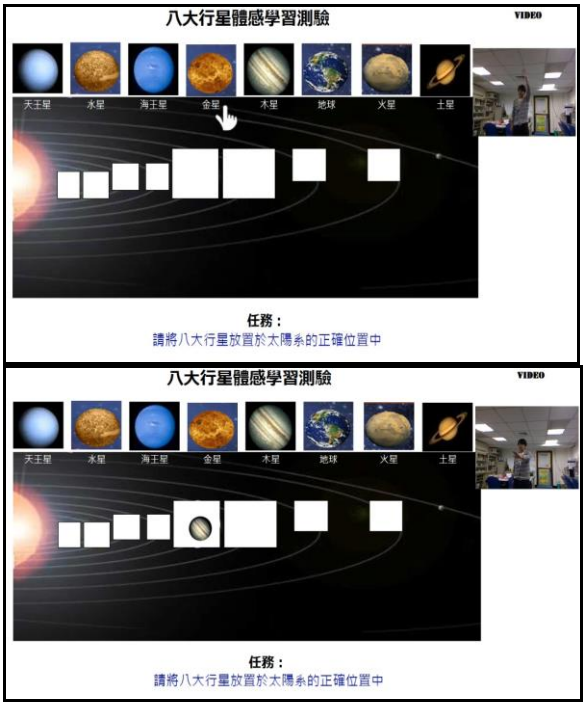

Figure 1. Solar system of KTSICM

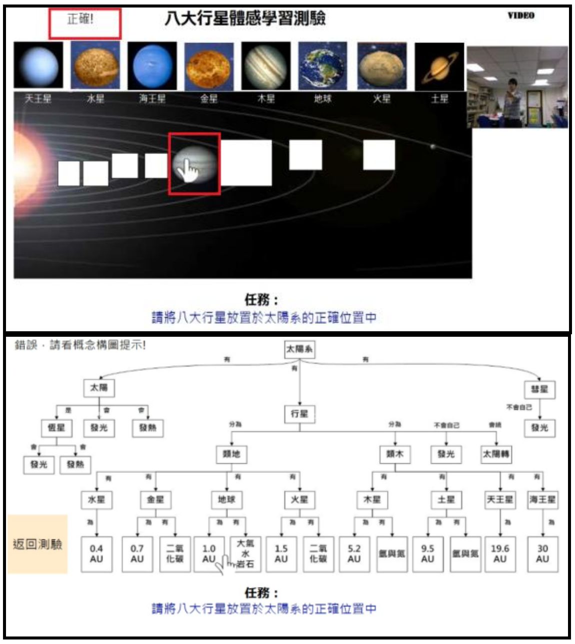

Figure 2. Immediate feedback of KTSICM

Following that, the KTSICM will automatically determine its own correct answers with immediate feedback responding to learners. If learners answer correctly, the KTSICM will show a message for a correct answer on the left upper screen corner. If learners answer wrongly, the KTSICM will feedback the prompting mechanism of concept maps with an error message shown on left upper screen corner in the same time alarmingly requesting for the corrective attention on the prompt of concept maps, as shown in Figure 2.

When the prompt of concept maps appears, learners can repeatedly reflect their own knowledge structure by focusing on concept maps to clarify misjudged concepts. Furthermore, in the form of gesture recognition, the hand icon on the screen can be dragged back to the buttons with testing icons or the previous testing screen after systematically default 30 seconds without any motion made. After learners complete learning tasks, it is available to find the correct positions of 8 major planets on the screen.

Experiment Design and Participants

This experiment is divided into 3 different groups with the difference mainly focused on the implementation of teaching strategies. This experiment randomly assigns learners to Group A, Group B and a Control Group separately featured with different teaching strategies. In view of experimental handling, all learners face the sameness of learning contents, prior tests and posterior tests, but teaching strategies are different. The design of experimental activities is described as Figure X. This experiment is composed of 3 different stages for prior tests, tool introduction and learning tasks as well as posterior tests and questionnaire surveys on cognitive load. In the 1st stage, all learners receive the prior tests of the basic knowledge about the courses of 8 major planets in Earth Science with a period lasting 10 minutes. In the 2nd stage, learners from 3 different groups are instructed about the tools and tasks purposed for learning activities with a period lasting 10 minutes. Thereafter, in the learning activities with a period lasting 20 minutes, learners from Group A (Concept map-oriented gesture-based teaching strategy) receive learning tests by using the kinetic teaching system combined with concept maps. Learners from Group B (Conventional gesture-based teaching strategy) receive learning tests through a generic kinetic teaching system. Learners from the Control Group (Traditional e-book teaching materials) conduct learning activities based on the teaching materials listed in E-books. In the final stage, the questionnaire surveys for posterior tests of basic knowledge and cognitive load are conducted with a period lasting 20 minutes. There are totally 3 different groups with 30 persons randomly assigned to each group. There are totally testees for this experiment. By excluding 2 invalid samples, there are totally 90 samples having this experiment completed.

RESEARCH RESULTS

The Effect of Prior Knowledge Test

This research is meant to explore the influence on learning achievements and cognitive load of learners caused by different teaching strategies. Therefore, before this experiment, the prior tests about the basic knowledge of 8 major planets in Earth Science is conducted and it aims to understand whether there is any significant difference happening to students receiving prior tests with basic knowledge about 8 major planets from 3 different groups. Variance homogeneity is rated at 0.704 without any significant level reachable and it means the variances of the test scores from 3 different groups are featured with homogeneity. The scores of prior tests are further conducted with the ANOVA analysis. From analytical results, it is found there is no significant difference happening to the prior tests among students ($p=.072>.05$) and this situation indicates students from 3 different groups have been equivalent prior knowledge of 8 major planets in Earth Science, as shown in table 1. Also, the difference of prior knowledge exerts no influence on learning achievements.

Learning Achievements of Posterior Tests

After this experiment is completed, students from 3 different groups receive the posterior tests about the knowledge of 8 major planets to understand whether there

Table 1 Descriptive statistics of students' prior knowledge

Group	N	Prior-test mean / S.D.	F
A	30	39.00/25.237	2.717
B	30	25.67/26.220	
Control	30	39.67/27.226	

Table 2. Descriptive statistics of students' learning achievements

Group	N	Learning Achievements mean / S.D.	F	Post-hoc
A	30	64.33/24.591	4.805*	Group A> Group B** Control Group > Group B*
B	30	44.33/30.250		
Control	30	58.00/20.910		

*p<0.05, **p<0.01

Table 3. Descriptive statistics of students' mental effort

Group	N	mean / S.D.	F	Post-hoc
A	30	7.27/2.638	5.621**	Group A< Group A**
B	30	9.53/2.360		
Control	30	8.23/2.861		

**p<0.01

Table 4. Descriptive statistics of students' mental load

Group	N	mean / S.D.	F
A	30	5.00/2.841	.591
B	30	5.67/2.187	
Control	30	5.60/2.774	

is any influence on learning achievements exerted by different teaching strategies. In view of the analytical results of the scores of prior tests, it has been already known there is no remarkable difference happening to the prior knowledge for 8 major planets in Earth Science among those students receiving prior tests. This research conducts the ANOVA analysis on the results of posterior tests. Examined results reveal different teaching strategies cause remarkable difference on the scores of posterior tests (p=.010<.05) , as shown in table 2.

Therefore, after the posterior comparison is done, from examined results, it is found the learning achievements of Group A is remarkably better than those of Group B (p=.003<.05). The learning achievements of the Control Group is remarkably better than those of Group B (p=.041<.05). However, there is no remarkable difference between Group A and the Control Group (p=.340>.05). Therefore, learners using 2 different ways of both the kinetic teaching system combined with concept maps and E-books for learning the courses of 8 major planets in Earth Science show better learning achievements than those of learners using a generic kinetic teaching system. For learners, when the comparison is made for 2 different learning ways of both the kinetic teaching system combined with concept maps and E-books separately, there is no remarkable influence found.

To understand whether there is any significant variance happening to the cognitive load among learners under different teaching strategies, this research conducts the ANOVA analysis on 2 different aspects of mental effort and mental load among learners separately. Questionnaire surveys are conducted by using a Likert 7-point Scale with "very agree" rated at 7 points, "agree" rated at 6 points, "slightly agree" rated at 5 points, "average" rated at 4 points, "slightly disagree" rated at 3 points, ”disagree” rated at 2 points and “very disagree” rated at 1 point. Higher scores mean heavier load. There are 90 valid replies received.

The dimension of mental effort means the effort spent by learners required to complete learning tasks. From results, it is found there is significant variance happening to learners from 3 different groups in the dimension of cognitive load ($p=.005<.01$). Through post-hoc comparison, it is found there is significant variance happening to load volume of the learners separately from Group A and Group B ($p=.001<.01$). The dimension of mental effort in Group A scores an average of 7.27. The dimension of mental effort in Group B scores an average of 9.53. This situation indicates when heavier mental effort is required by the learners from 2 different groups conduct learning activities. Also, the cognitive load from Group B is heavier than that from Group A, as shown in table 3.

In the dimension of mental load, it means learners burden heavier psychological stress. From results, it is found there is no significant variance happening to cognitive load among learners ($p=.556>.05$). It means the difficulty and load of learning activities are appropriate and it will cause no remarkably large psychological stress imposed on learners, as shown in table 4.

By summarizing the aforesaid statistical results, it is found learners show better learning achievements by using 2 different teaching strategies, namely the kinetic teaching system combined with concept maps and E-books, to learn the courses of 8 major planets in Earth Science than those learners by using the teaching strategies of generic kinetic teaching systems. From the influence on the cognitive load of learners under different teaching strategies, it is found learners using generic kinetic teaching systems to learn the courses of 8 major planets in Earth Science burden heavier cognitive load when compared with those learners using a kinetic teaching system combined with concept maps with significant influence on learning achievements consequently.

CONCLUSIONS

The results in this research reveal kinetic technologies combined with appropriate teaching strategies can effectively enhance the learning achievements of learners. However, when compared with the learners using traditional teaching materials of E-books, there is no significant influence on learning achievements and cognitive load. Therefore, the kinetic teaching system combined with concept maps developed by this research can be served as an alternative teaching system. Also, through innovative kinetic interaction, it is available to intensify the learning motivation and interest of learners. The results in this research are based on relevant educational theories indicated by the researchers in past scientific literatures to improve the learning achievements of learners with the integration of information technologies and teaching strategies (Hwang, Wu & Chen, 2007). Also, through the aids of a scaffolding learning framework, it is helpful for learners to complete and transcend the learning tasks within existing capabilities of learners (Wood, Bruner & Ross, 1976). Again, it is well testified the development of information technologies and teaching systems is required for appropriately adaptive teaching strategies to reach the importance with educational aids beneficial for learners. Additionally, only when effective learning strategies or tools are proposed can the learning achievements and learning performance of students be positively influenced. Otherwise, learning performance will be disappointing (Chen, 2009).

Furthermore, the kinetic teaching system appropriately combined with the teaching strategies of concept maps developed by this research can effectively improve the learning achievements of learners. It also proves the paper proposed by Barsalou (2008) bringing with the effect helpful for cognitive development through the involvement of limb motions. In educational activities, humane bodily motions can be used to materialize teaching materials no matter by means of a mentor or self-demonstration. Both are available for learners to enrich their knowledge performance or help themselves to acquire abstract concepts (Chang 2013). Thus, it is allowable for learners to conduct learning activities in a kinetic way with meaningful involvement of limb motions introduced into the learning process allowable for the brain to construct disciplinary knowledge through cognition. The cooperative interaction through meaningful limb motions is exactly the most natural and intuitive way to complete the conveyance and learning of disciplinary knowledge.

To sum up above mention, this research adopts kinetic technologies served as a supportive role for learning activities to develop a set of kinetic teaching system combined with concept maps. Also, the influential factors on learning achievements and cognitive load of learners are taken into consideration to explore effectiveness and practicality in teaching activities. It is further found the learning activities with the aids of a scaffolding framework can help learners gain excellent learning achievements. Furthermore, the kinetic teaching way uses humane bodily motions to materialize teaching materials helpful for learners to acquire the concepts of professional knowledge.

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REFERENCES

Anderson-Inman, L., & Ditson, L. (1999). Computer-based concept mapping: A tool for negotiating meaning. *Learning and Leading with Technology, 26*(8), 6-13.

Boyle, J. R., & Weishaar, M. (1997). The effects of expert-generated versus student-generated cognitive organizers on the reading comprehension of students with mild disabilities. *Learning Disabilities Research & Practice,12*, 228-235.

Barsalou, L. W. (2008). Grounded cognition. *Annual Review of Psychology, 59*(1), 617-645.

Chiu, C. H., Huang, C. C., & Chang, W. T. (2000). The evaluation and influence of interaction in network supported collaborative concept mapping. *Computers and Education, 34*(1), pp. 17-25.

Chu, H. C., Hwang, G. J., & Tseng, J. C. R. (2010). An innovative approach for developing and employing electronic libraries to support context-aware ubiquitous learning. *Electronic Library, 28*(6), pp. 873-890.

Chang, K. E., Sung, Y. T., Chang, R. B., & Lin, S. C. (2005). A new assessment for computer-based concept mapping. *Educational Technology & Society, 8*(3), pp. 138-148.

Chang, Y. J., Chou, L. D., Wang, F. T. Y., & Chen, S. F. (2013). A kinect-based vocational task prompting system for individuals with cognitive impairments. *Pers Ubiquit Comput, 17*, pp. 351-358.

Chen, C. M. (2009). Ontology-based concept map for planning a personalised learning path. *British Journal of Educational Technology, 40*(6), pp. 1028-1058.

Chen, N. S., Teng, D. C. E., Lee, C. H., & Kinshuk. (2011). Augmenting paper-based reading activity with direct access to digital materials and scaffolded questioning. *Computers & Education, 57*(2), pp. 1705-1715.

Chen, S. T., Chiang, I. T., Liu, E. Z. F., & Chang, M. (2012). Effects of improvement on selective attention: Developing appropriate somatosensory video game interventions for institutional-dwelling elderly with disabilities. *Turkish Online Journal of Educational Technology, 11*(4), pp. 409-417.

Chiang, I. T., Tsai, J. C.& Chen, S.T. (2012). Using Xbox 360 kinect games on enhancing visual performance skills on institutionalized older adults with wheelchairs. *2012 Fourth IEEE*

International Conference on Digital Game and Intelligent Toy Enhanced Learning, 263-267.
Chang, C. Y., Chien, Y. T., Chiang, C. Y., Lin, M. C., & Lai, H. C. (2013). Embodying gesture-based multimedia to improve learning. *British Journal of Educational Technology, 44*(1), pp. 5-9.
Clark, R., Pua, Y. H., Fortin, K., Ritchie, C., Webster, K., Denehy, L., & Bryant, A. (2012). Validity of the microsoft kinect for assessment of postural control. *Gait and Posture, 36*(3), pp. 372 – 377.
Dutta, T. (2012). Evaluation of the Kinect sensor for 3-D kinematic measurement in the workplace. *Applied Ergonomics, 43*, pp. 645-649.
Erdogan, Y. (2009). Paper-based and computer-based concept mappings: The effects on computer achievement, computer anxiety and computer attitude. *British Journal of Educational Technology, 40*, pp. 821-836.
Fischer, F., Bruhn, J., Grasel, C., & Mandl, H. (2002). Fostering collaborative knowledge construction with visualization tools. *Learning and Instruction, 12*, pp. 213–232.
Gordon, A. M., & Okita, S. Y. (2010). Augmenting pediatric constraint-induced movement therapy and bimanual training with video gaming technology. *Technology and Disability, 22*, pp. 179-191.
Grieser, J. D., Gao,Y., Ransdell, L., & Simonson, S. (2012). Determining Intensity Levels of Selected Wii Fit Activities in College Aged Individuals. *Measurement in Physical Education and Exercise Science, 16*, pp. 135-150.
Galatas, G., Ferdous, S., & Makedon, F. (2103). Multi-modal Person Localization And Emergency Detection Using The Kinect. *International Journal of Advanced Research in Artificial Intelligence, 2*(1), pp. 41-46.
Horton, P. B., McConney, A. A., Gallo, M., Woods, A. L., Senn, G. J., & Hamelin, D. (1993). An investigation of the effectiveness of concept mapping as an instructional tool. *Science Education, 77*, pp. 95–111.
Hsu, H. J. (2011). The Potential of Kinect in Education. *International Journal of Information and Education Technology, 1*(5), pp. 365-370.
Hughes, G., & Hay, D. (2001). Use of concept mapping to integrate the different perspectives of designers and other stakeholders in the development of e-learning materials. *BritishJournal of Educational Technology, 32*(5), pp. 557-569.
Hwang, G. J., Wu, T. T., & Chen, Y. J. (2007). Ubiquitous Computing Technologies in Education. Journal of Distance Education Technology, 5(4),1-4.
Hwang, G. J., Wu, P. H., & Ke, H. R. (2013). A concept map-embedded educational computer game for improving students' learning performance in natural science courses. *Computers & Education, 69*, pp. 121-130.
Huang, H. S., Chiou, C. C., Chiang, H. K., Lai, S. H., Huang, C. Y., & Chou, Y. W. (2012). Effects of multidimensional concept maps on fourth graders' learning in a web-based computer course. *Computers & Education, 58*(3), pp. 863-873.
Jaimesa, A., & Sebe, N. (2007). Multimodal human–computer interaction: A survey. *Computer Vision and Image Understanding, 108*, pp. 116-134.
Johnson, L. F., Levine, A., Smith, R. S., & Haywood, K. (2010). Key Emerging Technologies for Postsecondary Education. *The Education Digest, 76*(2), pp. 34-38.
Kao, G. Y. M., Lin, S. S. J., & Sun, C. T. (2008a). Breaking concept boundaries to enhance creative potential: using integrated concept maps for conceptual self-awareness. *Computers & Education, 51*, pp. 1718-1728.
Kao, G. Y. M., Lin, SS. J., & Sun, C. T. (2008b). Beyond sharing: engaging students in cooperative and competitive active learning. *Educational Technology & Society, 11*(3), pp. 82-96.
Kwon, S. Y., & Cifuentes, L. (2009). The comparative effect of individually-constructed vs. collaboratively-constructed computer-based concept maps. *Computers & Education, 52*, 365–375.
Kean, S., Hall, J., & Perry, P. (2011). Meet the Kinect: An Introduction to Programming Natural User Interfaces. CA: Apress.
Liu, C. C., Don, P. H., & Tsai, C. M. (2005). Assessment based on linkage patterns in concept maps. *Journal of Information Science and Engineering, 21*(5), pp. 873-890.

Liu, T. C., Peng, H. Y., Wu, W. H., & Lin, M. S. (2009). The effects of mobile natural-science learning based on the 5E learning cycle: A Case Study. *Educational Technology & Society, 12*(4), pp. 344-358.

Liu, P. L., Chen, C. J. & Chang, Y. J. (2010). Effects of a computer-assisted concept mapping learning strategy on EFL college students' English reading comprehension. *Computers & Education, 54*, pp. 436-445.

Liu, P. L. (2011). A study on the use of computerized concept mapping to assist ESL learners' writing. *Computers & Education, 57*(4), pp. 2548-2558.

Liu, S. H. & Lee, G. G. (2013). Using a concept map knowledge management system to enhance thelearning of biology. *Computers & Education, 68*, pp. 105-116.

Lee, C. H., Liu, C. L., Chen, Y. A., & Chen, Y. S. (2011). Painting in the air with Wii Remote. *Computers & Education, 38*, pp. 14668-14678.

McCagg, E. C., & Dansereau, D. F. (1991). A convergent paradigm for examining knowledgemapping as a learning strategy. *Journal of Educational Research, 84*(6), pp. 317–324.

Mantzicopoulos, P., & Patrick, H. (2010). The Seesaw is a machine that goes up and down: Young children's narrative responses to science-related informational text. *Early Education and Development, 21*(3), pp. 412-444.

Mentiplay, B. F., Clark, R. A., Mullins, A., Bryant, A., Bartold, S., & Kade, P. (2013). Reliability and validity of the Microsoft Kinect for evaluating static foot posture. Mentiplay et al. Journal of Foot and Ankle Research, 6(14), pp. 1-10.

Novak, J. D., & Gowin, D. B. (1984). Learning how to learn. Cambridge, Lodon: Cambridge University Press.

Novak, J. D., & Musonda, D. (1991). A twelve-year longitudinal study of science concept learning. *American Education Research Journal, 28*, pp. 117-153.

Novak, J. D., & Cañas, A. J. (2006). The origins of the concept mapping tool and the continuing evolution of the tool. *Information Visualization, 5*, pp. 175-184.

Okebukola, P. A., & Jegede, O. J. (1988). Cognitive preference and learning mode asdeterminants of meaningful learning through concept mapping. *Science Education, 72*, pp. 489-500.

Paas, F. G. W. C. (1992). Training strategies for attaining transfer of problem solving skill in statistics: A cognitive load approach. *Journal of Educational Psychology,84*(4), pp. 429-434.

Paas, F. G. W. C., & van Merriënboer, J. J. G. (1993). The efficiency of instructional conditions: An approach to combine mental effort and performances. *Human Facto, 35*, pp. 737-747.

Paas, F. G. W., & van Merriënboer, J. J. G. (1994). Variability of worked examples and transfer of geometrical problem solving: A cognitive load approach. *Journal of Educational Psychology, 86*, pp. 122-133.

Paas, F. G. W. C., Renkle, A., & Sweller, J. (2003). Cognitive load theory and instructional design: Recent developments. *Educational Psychologist, 38*(1), 1-4.

Panjaburee, P., Hwang, G. J., Triampo, W., & Shih, B. Y. (2010). A multi-expert approach for developing testing and diagnostic systems based on the concept effect model. *Computers & Education, 55*, pp. 527-540.

Qian, K., Niu, J., & Yang, H. (2013). Developing a Gesture Based Remote Human-Robot Interaction System Using Kinect. International Journal of Smart Home, 7(4), pp. 203-208.

Roth, W. M., & Roychoudhury, A. (1994). Science discourse through collaborative conceptmapping: New perspectives for the teacher. *International Journal of Science Education, 16*, pp. 437-755.

Sweller, J. (1988). Cognitive load during problem solving: Effects on learning. *Cognitive Science, 12*, pp. 257-285.

Sweller, J. (1989). Cognitive technology: Some procedures for facilitating learning and problem solving in mathematics and science. *Journal of Educational Psychology, 8*1, pp. 457-466.

Sweller, J., van Merriënboer, J. J. G., & Paas, F G. W. C. (1998). Cognitive architecture and instructional design. *Educational Psychology Review, 10*(3), pp. 251-285.

Southwell, B. J. & Fang, G. (2013). Human Object Recognition Using Colour and Depth Information from an RGB-D Kinect Sensor. *International Journal of Advanced Robotic Systems, 10*, pp. 1-10.

Trent, S. C., Pernell, E., Jr., Mungai, A., & Chimedza, R. (1998). Using concept maps to measure conceptual change in preservice teachers enrolled in a multicultural education/special education course. *Remedial and Special Education, 19*, pp. 16–30.

Tong, J., Zhou, J., Liu, L., Pan, Z., & Yan, H. (2012). Scanning 3D Full Human Bodies Using Kinects. *IEEE Transactions on Visualization and Computer Graphics, 18*(4), pp. 643-650.

Vernadakis, N., Gioftsidou, A., Antoniou, P., Ioannidis, D., & Giannousi, M. (2012). The impact of Nintendo Wii to physical education students' balance compared to the traditional approaches. *Computers & Education, 59*, pp. 196-205.

Wood, D., Bruner, J., & Ross, G. (1976). The role of tutoring in problem solving. *Journal of Child Psychology and Psychiatry and Allied Disciplines, 17*, pp. 89-100.

Weise, T., Bouaziz, S., Li, H., & Pauly, M. (2011). Real time performance-based facial animation. *ACM Transactions on Graphics, Proceedings of the 38th ACM SIGGRAPH Conference*, 30 (4). pp. 1-10.

Wachs, J. P., Kolsch, M., Stern, H., & Edan, Y. (2011). Vision-based handgesture applications, Commun. *ACM, 54*, pp. 60-71.

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