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On the Push-pull Mobile Learning of Electric Welding

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ABSTRACT
This study aims to explore the learning effects and attitudes of students in the course electric welding practice in a university of science and technology to which the push-pull technology-based mobile learning system is applied. In this study, the push-pull technology is adopted to establish a mobile learning system and develop the Push-pull Course of Special Topic Mobile Learning of Electric Welding, which includes three parts - (1) the instruction of the electric welding course, (2) the learning of the electric welding course, and (3) the multi-dimensional evaluation of the electric welding course. Two classes of the course in the department of engineering science of university of science and technology were taken as the research subjects for the experimental instruction, with 61 students in the Experimental Group and 58 in the Control Group. Throughout the instruction, the questionnaire and written information about the students were collected and analyzed so as to explore the influence of "Push-pull Mobile Learning Course of Electric Welding" on the academic performance and attitude. Here are the conclusions of this study: (1) the course can significantly improve the students' learning of electric welding; (2) students hold a positive attitude towards the course; (3) the course can facilitate the students' discussions, learning effects and cooperative learning. Also, this study gives some suggestions for the instruction of the course, so as to enhance students' knowledge and skills of electric welding and promote the significance of the course.
Keywords: electric welding; engineering education; mobile learning; push-pull technology

INTRODUCTION

As the cloud computing technology becomes increasingly mature and the wireless network and portable technology develop rapidly, information has become accessible everywhere and learning has become highly interactive and sharing-oriented, which has changed the learning environment for students (Tsai & Lou, 2014). It has not only shuttered the restriction of the

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State of the literature

- Specific Topic-based Curriculum could deepen students' understanding of basic concepts, enhance their creativity, consolidate their academic foundation and help them with a further study.
- Mobile learning is a digital learning method where such technologies as mobile devices and the Internet are used to spread knowledge, so that learners can receive education at any time and at any place through mobile telephones or personal digital assistant (PDA).
- Push-pull technology enables users to utilize the resources on the Internet at any time and at any place to create an environment without the restriction in time and space.

Contribution of this paper to the literature

- The Push-pull Course of Special Topic Mobile Learning of Electric Welding consists of three parts - instruction, learning and multi-dimensional evaluation.
- The Push-pull Course of Special Topic Mobile Learning of Electric Welding can significantly enhance the students' learning effects of electric welding.
- The students show a positive learning attitude towards the Push-pull Course of Special Topic Mobile Learning of Electric Welding.

traditional instruction field but also promote the trend of mobile learning (Shen, 2012; Liu, Dai & Lu, 2015; Zydney & Warner, 2016). According to Al-Emran, Elsherif and Shaalan (2016) as the action-based technology advances rapidly, mobile phone has become a widely-used digital communication tool and the push/pull of information on mobile phones has become increasingly important. Therefore, all communication practitioners strive to offer the services about the push/pull of written and multimedia information (Lou, Cheng & Kuo, 2015). Smart phones are a communication tool which can be linked with the Internet to obtain the rich, diverse and immediate information on the Internet, which can facilitate mobile learning, enhance learning motive and improve learning effects (Sarrab, Elbasir & Alnaeli, 2015). If the push-pull technology is adopted to establish the mobile learning system and is used in vocation education, remarkable achievements can be expected.

Vocational education is supposed to train basic talents for the national economic development. With emphasis on the integration of theory and practice, it aims to develop basic technicians (Barnes, Christensen & Hansen, 1994). So far as the students of universities of science and technology are concerned, furnishing them with expertise and skills plays a dominant role. The most representative course that equips the students with professional skills is Electric Welding Practice, which is also the first practical course for the freshmen in the school. If students can acquire the electric welding skill and become passionate about engineering through the course, it will greatly improve their learning in the four-year college life (Lou, Dzan, Lee & Chung, 2014). For long, the instructor-centered instruction model has been adopted in the traditional education, where instructors dominate the entire instruction and often neglect students' feeling in the delivery of knowledge and skills (Meyer, 2007). Craft, Hall and Costello (2014) believed that a successful instruction underlines knowledge and a successful instruction design included such special topic-based learning activities as instruction theme, cooperative learning, and the interaction and dialogue among instructors and students (Lou, Tsai & Tseng, 2011). Additionally, the instructors in the new century should think about how to incorporate information technology into instruction, so as to guide students to collect information with technologies to accelerate their learning and ignite their passion for learning (Hadjilouca, Constantinou & Papadouris , 2011).

However, mobile learning (m-learning) features in the design integrating both mobile devices and learning environment. The highly portable characteristic of mobile devices is effectively applied to create an environment in which you can learn at any time and obtain resources. It can increase the availability of interaction between teachers and peers and provide specific instruction based on individual demands (Motiwalla, 2005). In addition, the connectivity of m-learning can link mobile devices and data storage devices to create an environment for sharing, receiving, and sending information at any time. It breakthroughs the limits of time and space, achieves real time exchange of data, cooperation, and interaction so as to enhance communication and strengthen social interactivity (Klopfer, Squire & Jenkins, 2002).

Therefore, this study designs a push-pull mobile learning system and plans the Push-pull Course of Special Topic Mobile Learning of Electric Welding and applies the system to the course in a university of science and technology. Giving priority to the student-centered learning method, it aims to enhance students' interest in learning through group learning and implement the principle of "learning by doing" in vocational education (Lou, Chung, Dzan, Tseng & Shih, 2013). Here are the three purposes of this study:

(1) Develop the Push-pull Course of Special Topic Mobile Learning of Electric Welding in a university of science and technology.
(2) Explore the role of the course in enhancing the students' learning in the electric welding course.
(3) Analyze the role of the course in changing the students' attitude towards the electric welding course.

LITERATURE REVIEW

The literature on the special topic-based curriculum, the mobile learning and the push-pull technology is organized as follows.

Specific Topic-based Curriculum

"Special topic" is planned for combining the theories and practical skills students have acquired to strengthen their learning motive and develop their abilities of independent thinking and teamwork (Hsiao, 1997; Moursund, 1999). It was found in the research by Mahendran (1995) that special topic could deepen students' understanding of basic concepts, enhance their creativity, consolidate their academic foundation and help them with a further study (Lou, Tsai & Tseng, 2011), so that they would be able to experience product design, problem-solving method, decision-making and product development through the special topics and then get the opportunity to do independent work and attain achievements (Perez-Benedito, Perez Alvarez, & Casati, 2015; Yueh, Liu & Lin, 2015).

In the special topic course of electric welding in this study, the special topic-based instructional strategies are applied to the course of electric welding practice in a university of science and technology. After the students acquire the basic knowledge and skills of electric welding, there is the practice of the special topic-based course of electric welding, where some topics are designed to lead students to detect topic-related problems. Through the application of the mobile learning system, students are expected to improve their learning, develop the ability to collect information, accumulate experience in creating special topics, and strengthen their abilities of application and analysis, comprehensive ability, and value-judging ability.

Mobile Learning

Mobile learning is a digital learning method where such technologies as mobile devices and the Internet are used to spread knowledge (Wang, Lin & Luarn, 2006) so that learners can receive education at any time and at any place through mobile telephones or personal digital assistant (PDA) (Tabuenca, Kalz, Drachsler & Specht, 2015). In mobile learning, different senses including vision, hearing and touch can be used to enhance their learning; hence, it is convenient, immediate, adjustable, maneuverable, ubiquitous and portable (Chang, Liang, Yan & Tseng, 2013). Moreover, what to be taught can be efficiently presented through mobile devices and it offers bilateral communication between instructors and learners and enables learners to study at any time and at any place (Huan, Li, Aydeniz & Wyatt, 2015). In modern education, more and more attention is paid to students and instructors should make full use of various teaching devices, resources and other multimedia to support instruction, offer diverse learning methods, and ignite students' passion for learning, so as to enhance the effects of instruction (Chen, Hsieh & Kinshuk, 2008). As smart phones and tablets prevail, mobile learning will be an inevitable trend in the learning in the present-day world.

Therefore, in recent years, many researches on m-learning had been published. In terms of the improvement of academic performance, Pu, Wu, Chiu and Huang (2016) applied m-learning technology to the design of practice course of higher vocational nursing so as to enhance the practical experience and professional skills of students majoring in nursing. In terms of the evaluation of effectiveness of m-learning, Huang and Chiu (2015) assumed that meaningful learning of theories shall be considered as the basis to evaluate the effectiveness of context-aware m-learning (CAML) and suggested that the developers of CAML shall increase the applications of m-learning in study via the increase of the value of learning activities. Besides, as of teaching practices, Biddix, Chung and Park (2016) adopted mobile information and communication technology (m-ICT) as a tool to transmit teaching content and facilitate learning, explored its use by teachers and awareness, and suggested that technology and social interactive elements should be integrated in the development of m-learning in the future. The aforementioned literature shows that the application of m-learning in assisted

Table 1. Comparison of learning models

Item	Traditional Education	e-learning	m-learning
Teaching media	OHP, slide, Tape	MPC + Internet + digital teaching materials	Mobile devices + Wi-Fi or PCS (GSM, PHS, 3G) + digital teaching materials
Limits of time and space	Most limits	Fewer limits	Fewest limits
Learning methods	To assist instruction at classroom	Student must use computer for study.	Student can use mobile devices to learn any time.
Information acquisition	To be provided by teachers	Knowledge is provided by teacher or the Internet	Knowledge is provided by teacher or the Internet real-time.
Learning activities	Mainly indoor	Mainly indoor	Real-time

instruction has material and effective results. Hence, m-learning and other learning models were compared, as shown in **Table 1**. In short, technology is a main driving force for learning (Alexandrov, 2014). With the strength of modern educational technology, many teaching activities that cannot be held in the traditional classroom can be held today, including the interaction between teachers and students and the dynamic instruction based on visual and audio effects, so that students can undertake free learning, exploration and discussions (Laabidi, Jemni, Ayed, Brahim & Jemaa, 2014).

Based on the features that mobile learning is convenient and immediate and users are active and the use of mobile learning is interactive, this study plans and designs the Mobile Learning in the special topic-based course of Electric Welding in a university of science and technology and develops the Special Topic-based Mobile Learning of Electric Welding, so that students will be able to gain the knowledge and skills of electric welding through the mobile learning system.

Push-pull Technology and Mobile Learning

The mobile learning system in this study is designed with the technology of push-pull. In the application environment of push-pull technology, situation information is taken as a condition for granting users permissions. In the process, permissions are granted to users according to their situations (Sejong, 2010; Wu & Fan, 2012). Push-pull technology enables users to utilize the resources on the Internet at any time and at any place to create an environment without the restriction in time and space. It is a combination of the Internet environment, information devices, device platforms and information. With such an Internet environment architecture, all people can have an access to the Internet through any devices (PDA, smart phones and laptops) at any time and at any place and feel the convenience of obtaining resources (Martin, Diaz, Plaza, Ruiz, Castro & Peire, 2011; Wu & Fan, 2012).

There are only two models of information delivery on the Internet, the Technology Push and the Need Pull (Push/Pull). With the Push/Pull technology, the Google GCM Cloud Push/Pull service, and the highly available HTTP server, this study establishes a general

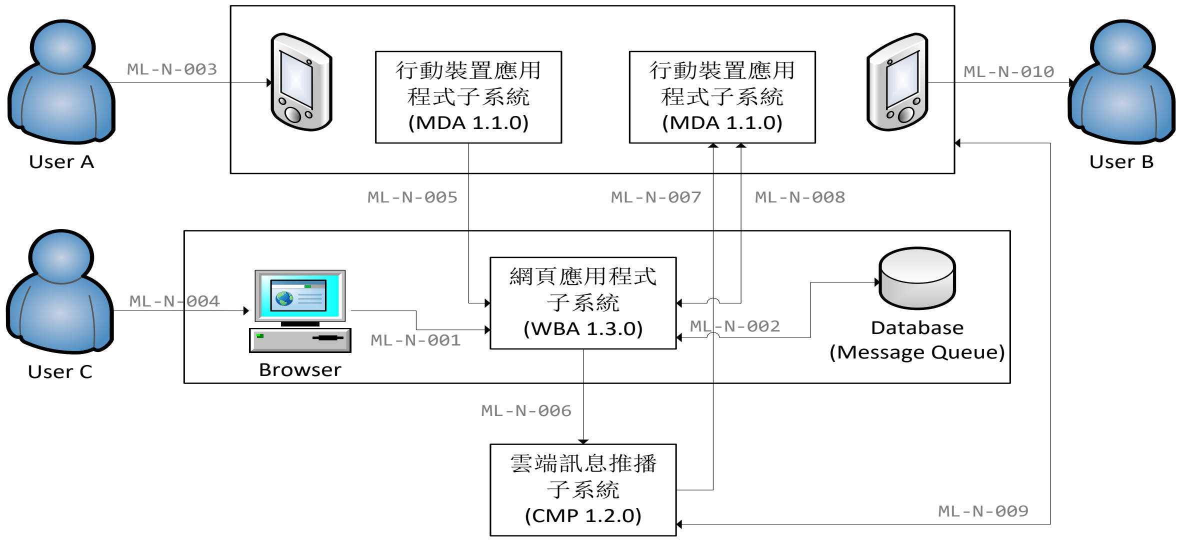

Figure 1. System architecture graph

push/pull service platform to achieve active push/pull and reception of information and match the behaviors of the users of smart mobile devices today. Moreover, this study offers the solutions of web page application programs, so that the users without any mobile devices can receive and deliver information through the web page browsers. In this study, the action push-pull technology proposed by Lou, Cheng and Kuo (2015) is employed to build the mobile learning system, which is shown in **Figure 1**. There are three subsystems, and their internal and external interface functions are shown in **Tables 2** and **3**. Here are some details:

(1) The subsystem of mobile device application program:

It downloads the information that cannot be obtained by users, analyzes the multimedia contents and present them on the screen. Through the web page backstage program, it reviews information on the servers on a regular basis (through polling) and downloads the information to mobile devices. Also, users can make response or input and send new information through the APP.

(2) The subsystem of cloud information push/pull:

It includes all parts necessary for the cloud notification, including the acquisition and updating of the grant tokens of the server use service, the acquisition and updating of the service registration ID of all users, and the judgment of the information delivery and notification of the operation system of mobile devices.

(3) The subsystem of web page application program:

It is an interface for the communication between mobile devices and the servers. It has such functions as the communication among the databases of the servers, the saving and acquisition of information, the downloading of archives, and the control over online situation.

Table 2. Internal Interface Functions

Number	Description of Demand
ML-N-001	The web page application program can store and select information and manage and monitor personal resources through the servers.
ML-N-002	All information and the account information of all users can be stored and selected through the servers.
ML-N-007	It can judge the operation system of mobile devices and deliver information to mobile devices.

Table 3. External Interface Functions

Number	Description of Demand
ML-N-003	Users can control the program through the APP UI interface of mobile devices.
ML-N-004	Users can enter the web page through web page browsers and store and select information through the application program.
ML-N-005	The APPs of mobile devices can deliver information through the HTTP POST of SSL.
ML-N-006	It is necessary to deliver information through the cloud notification service interface when users are confirmed offline.
ML-N-008	Routine actions can be achieved through the APPs of mobile devices, including the acquisition of information and the downloading of multimedia archives.
ML-N-009	The APPs of mobile devices can be uploaded to cloud and notify the servers to register a unique ID.
ML-N-010	Users can receive and read information and notices through the APPs.

Table 4. Comparison of the functions of Push-pull m-Learning

Item	e-Learning	M-Learning	Push-pull m-Learning
Physical devices	Wired	Wireless	Disappeared
Computation & communication	distinctive	distinctive	Blurry
Learning	Confined to the single desk	Dynamic	Flexible
Methods to transmit information	Pull	Pull	Push Service
Feedback of learning context	Low	Moderate	High
Location-based exploration	Low	Moderate	High

In short, the advantage of mobile learning and push-pull technology is that students can receive customized Scaffolding instruction and support to observe and experience situations in the real world and establish their personal knowledge framework (Hwang, Tsai & Yang, 2008). As shown in **Table 4**, based on the existing advantages of m-learning, the efficiency of Push service is enhanced so that technology can satisfy on demand more seamlessly and meet the goal of real-time learning of students (Lou, Cheng & Kuo, 2015). In the interaction between the real environment and the learning system, students develop independent thinking and enhance learning motive to attain more academic achievements (Chu, Hwang & Tsai, 2010).

Therefore, this study adopts the push-pull technology to establish the mobile learning system (Lou, Cheng & Kuo, 2015), develop the Push-pull Course of Special Topic Mobile Learning of Electric Welding of a university of science and technology, and utilize mobile devices (smart phones) to provide a complete, popular and interactive mobile learning

Table 5. Experiment Design of the Special Topic-based Course of the Mobile Learning of Electric Welding

Group	Pre-test	Experimental treatment	Post-test
Experimental group	O_1	X_1	O_2、O_3
Control group	O_1	X_2	O_2、O_3

environment, so as to integrate, connect and share educational resources and improve students' learning in the course.

RESEARCH DESIGN AND IMPLEMENTATION

According to the research objectives and literature review, this study is designed and implemented as follow:

Research Design

In this study, the experimental instruction is adopted to explore the influence of the Push-pull course of Special Topic Mobile Learning of Electric Welding on the learning effect and attitude of the students in a university of science and technology in their acquisition of the knowledge and skills of electric welding. Two classes of freshmen in the course of Electric Welding Practice are taken as the research subjects. One class is the Experimental Group of 61 students; the other is the Control Group of 58 students. According to **Table 5**, Mobile Learning is used for the experiment, with the Experimental Group taking the Push-pull Course of Special Topic Mobile Learning of Electric Welding while the Control Group the Special Topic-based Course of Electric Welding.

According to the question bank of the Level II Test on electric welding, this study designs the Electric Welding Learning Questionnaire, which consists of 20 items about the electric welding technology and 20 items about the electric welding safety, and there is also a statistical analysis of the pre-test and post-test. As for the learning effect of electric welding skills, there is a statistical analysis of the results of five electric welding practice assignments and the total score of the course according to the contents of course. Additionally, this study designs the Self-assessment Questionnaire of the Learning Attitude of the Students of the Push-pull Course of the Mobile Learning of Electric Welding, which comprises four dimensions. Here are the four Cronbach' α coefficients: the reliability of learning effect is .935; the reliability of learning behavior is .918; the reliability of cooperative learning is .928; the reliability of the use of the mobile learning system is .919. The reliability of the total scale is .954, which indicates a high level of internal consistence of the scale and is over the requirement (over .7) (Nunnally, 1978). The Likert Scale is used to evaluate the recognition of the research subjects who are asked to choose one of the following five items, namely, "Strongly Agree", "Agree", "Average", "Disagree" and "Strongly Disagree". Meanwhile, the feedback of the students and the qualitative analysis of the written reports are provided and the results of the quantitative analysis are demonstrated. Here is the instruction to the text encoding principle. Take "S8-3" for an example. "S" refers to the text information of the students; "8" means the eighth group; "3" indicates the third student in the group.

O1: Pre-test on the knowledge of electric welding of the Experimental Group and the Control Group, including the "Knowledge of the Electric Welding Technology" and the "Knowledge of the Safety of Electric Welding".

X1: The instruction of the Push-pull Course of Special Topic Mobile Learning of Electric Welding for the Experimental Group.

X2: The instruction of the Traditional Special Topic-based Course of Electric Welding for the Control Group.

O2: The assessment of the practical skills of electric welding of the Experimental Group and the Control Groups; there are five assignments of electric welding practice, along with the total score of the practical course in an electric welding factory this semester.

O3: The post-test on the knowledge of electric welding of the Experimental Group and the Control Group, including the scores in the post-test on the "Knowledge of the Electric Welding Technology" and the "Knowledge of the Safety of Electric Welding".

The Design of the Push-pull Course of Special Topic Mobile Learning of Electric Welding

This study makes the proposal of applying the push-pull technology to mobile learning and takes it as an instruction strategy of the electric welding practice course to develop the Push-pull Course of Special Topic Mobile Learning of Electric Welding and undertake experimental instruction through group work. The instruction field of the electric welding course for the Control Group is dominated by the face-to-face instruction in the electric welding practice factory; the instruction field of the electric welding course for the Experimental Group consists of both the face-to-face instruction in the electric welding practice factory and the course of mobile learning.

This study fully integrates the push-pull technology with the advantages and features of mobile learning for the curricular design of the Push-pull Course of Special Topic Mobile Learning of Electric Welding. As is shown in **Figure 2**, the course includes three parts - (1) the instruction of the electric welding course, (2) the learning of the electric welding course, and (3) the multi-dimensional evaluation of the electric welding course. Here are the details:

(1) The instruction of the electric welding course

The instructor introduces the focuses of the course of electric welding. In Week 1, the instructor links the course with the knowledge and experience students have accumulated during the vocational school years to develop their interest in the course. Then, the instructor

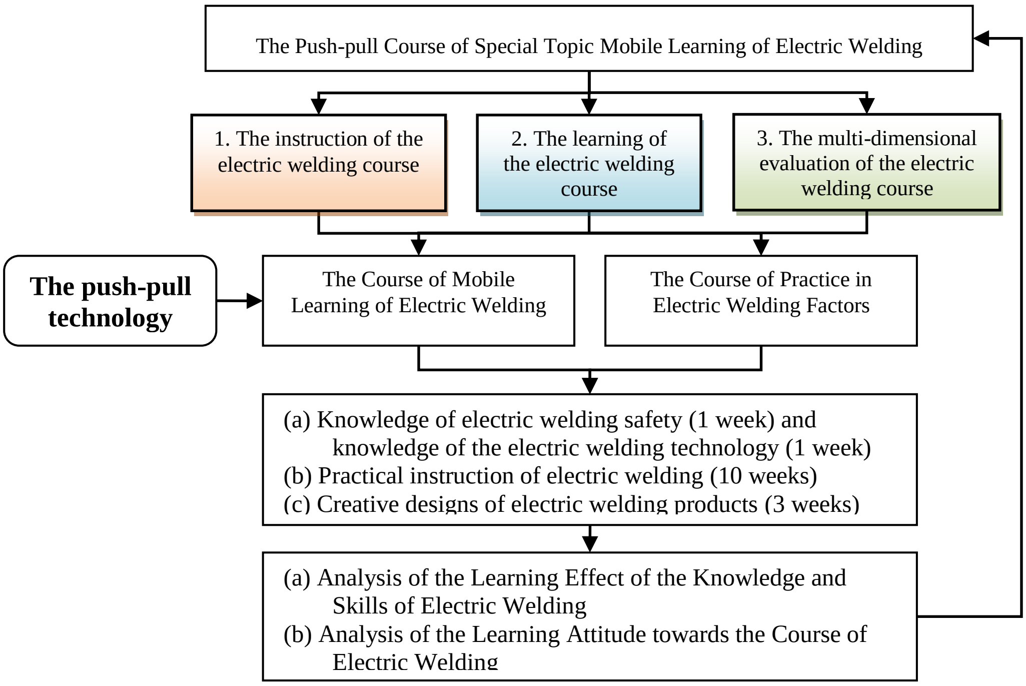

Figure 2. Curricular Design of Push-pull Course of Special Topic Mobile Learning of Electric Welding

gives a clear description of the learning objectives of all units in the course and encourages students to become involved in the instruction. Last, the instructor holds the pre-test to see the knowledge students have mastered and then adjust what to be taught. After that is the 15-week course of electric welding, which consists of 1 week for the knowledge of electric welding safety, 1 week for the knowledge of the electric welding technology, 10 weeks for the practical instruction of electric welding, and 3 weeks for creative designs of electric welding products. Specifically, the practical instruction of electric welding includes five units -- Leveled Welding of Steel Plate, Horizontal Welding of Steel Plate, Vertical Welding of Steel Plate, Upward Welding of Steel Plate, and Tubular Axis Welding. Each unit lasts for two weeks, and each student needs to submit the practical assignments of the five units which will be taken as the score of their electric welding practice. In the last week, three instructors assess the creative products and written reports of students and give awards to those students with excellent products. Afterwards, the instructor undertakes the post-test questionnaire to see the learning effects of students and find out what to be improved in the instruction. For the last step, the instructor summarizes the focuses of the course and share students' academic achievements and how they design the creative products.

This study emphasized student-centered learning models. As of the experimental group, besides the aforementioned teaching activity held at electric welding plants for internship, course related to electric welding of Push-pull m-learning system had been added. In Week 1, the instruction about the grouping and use of the mobile learning system is added. The

Figure 3. Function Options

Figure 4. Title Contents

Figure 5. Additional Archives

function of storage and selection of the database of the mobile learning system can be used to achieve such functions as the provision of digital textbooks, the evaluation of students, and the inquiry into comprehensive tests and the results of the evaluation, as is shown in **Figure 3**. The instructor can upload digital materials about the safety and skills of electric welding and evaluation tests for the independent learning of students. Moreover, the active push-pull function of the mobile learning system can be used to deliver the warming-up questions and evaluation ones about electric welding before the course on a regular basis, and the students are encouraged to join group discussions, as is shown in **Figure 4**. Meanwhile, students can use the additional archive functions of the mobile learning system to submit the assignments and pictures of the learning portfolios of the course, such as the pictures, tapes and videos of electric welding practice, as is shown in **Figure 5**. Students should be led to acquire the knowledge and skills of electric welding and develop the ability of independent learning. Students in groups can even make use of the immediate response function of the mobile learning system to discuss these topics and making of creative electric welding products and thus enhance teamwork.

(2) The learning of the electric welding course

This study adhered to the philosophy of learning while doing and asked students to learn the electric welding course based on their teacher guidance and finish the homework assigned by their teacher in order and creative design of electric welding. For the Experimental Group, this study adds the instruction strategies of the push-pull mobile learning system to help students with their independent acquisition of the knowledge and skills of electric welding. With the digital materials like the knowledge, pictures and instruction videos of electric welding in the mobile learning system, students can study at any time and at any place and finish the assignments and discussions assigned by the instructor. Moreover, students can make use of the immediate interaction of the mobile learning system to discuss the creative designs of electric welding products, including (a) the definition of topic where students can

Figure 6. Lists of Evaluation Results

Figure 7. Evaluation Result

independently choose a topic and introduce the motive of creative thinking; (b) the making of the design blueprint where students are asked to draw a conceptual design graph and elaborate on the design principle; (c) the introduction to practical experience in electric welding where students are asked to introduce the application of the electric welding technology according to the creative electric welding products and write down the feeling. All these steps will give a clear picture of students' learning and the making of their products. For the last step, students are required to submit their written reports.

(3) The multi-dimensional evaluation of the electric welding course

The multi-dimensional evaluation includes (a) the pre-test on the knowledge of electric welding and the safety of electric welding which aims to check students' understanding of electric welding; (b) post-test which consists of the knowledge of the electric welding technology and the safety of electric welding, the scores of the assignments of electric welding practice of the five units, and the total score of the practical course in the electric welding factory this semester. For the Experimental Group, this study adds the self-evaluation test of the push-pull mobile learning system. There are self-evaluation tests based on the units in the courses, which show students how much knowledge of electric welding they have acquired, as is shown in **Figures 6** and **7**. Moreover, students would get the results shortly after the evaluation. After the course, students' scores in the pre-test and the post-test will be used for a statistical analysis to check their learning effects and be taken as a basis for the curriculum design of the course of electric welding practice in the factory.

RESULTS AND DISCUSSION

According to the research design and implementation, the questionnaire and other written information about students are collected for quantitative and qualitative analysis of the change to students' learning effect and attitude after the Push-pull Course of Special Topic Mobile Learning of Electric Welding and their learning portfolios in the course.

Table 6. Analysis of the Paired Sample t Test on the Learning Effect of the Knowledge of Electric Welding

Type	Variable name	N	Mean	SD	*t*	*p*
Knowledge of the electric welding technology	Pre-test	61	9.84	2.368	-3.025	0.004
	Post-test	61	11.91	2.563		
Knowledge of electric welding safety	Pre-test	61	9.56	2.778	-5.210	0.000
	Post-test	61	12.15	2.455		

Analysis of the Learning Effect of the Knowledge and Skills of Electric Welding

As far as the learning effect of the knowledge and skills of electric welding is concerned, this study made a statistical analysis of the students' scores of electric welding knowledge, their scores in the five units of electric welding practice, and the total scores this semester. Here are the details of the analysis:

(1) Statistical analysis of the pre-test and post-test on the knowledge of electric welding of the students in the Experimental Group

The knowledge of electric welding in this study includes the "knowledge of the electric welding technology" and the "knowledge of electric welding safety". The pre-test and post-test for the Experimental Groups were used for the t test of paired samples to see the influence of the course on the students' learning of electric welding. The analytic results are shown in **Table 6**. The t value of the knowledge of the electric welding technology of the Experimental Group is -3.025 ($p=.004<.05$) and the t value of the knowledge of the electric welding technology is -5.210 ($p=.000<.05$). The mean of the post-test is significantly higher than that of the pre-test, which indicates that the students have made significant progress in the learning of the "knowledge of the electric welding technology" and the "knowledge of electric welding safety" after the course. Then, the Experimental Group and the Control Group were compared.

(2) Statistical Analysis of the Knowledge of Electric Welding of the Experimental Group and the Control Group

This study made an independent sample t test on the learning of the "knowledge of the electric welding technology" and the "knowledge of electric welding safety" of the Experimental Group and the Control Group. As is shown in **Table 7**, the t value of the "knowledge of the electric welding technology" is 1.275 ($p=.047<.05$) and the t value of the "knowledge of electric welding safety" is 2.118 ($p=.036<.05$). The post-test mean of the Experimental Group is significantly higher than that of the Control Group. This manifests that the Experimental Group have achieved greater learning effects than the Control Group in the "knowledge of the electric welding technology" and the "knowledge of electric welding safety" after the Push-pull Course of Special Topic Mobile Learning of Electric Welding.

In summary, different from the control group which only received traditional classroom teaching of electric welding course, the experimental group received the teaching materials, pictures, and exercises of electric welding course from time to time via Push-pull m-learning

Table 7. Analysis of the Independent Sample t Test on the Learning Effect of the Knowledge of Electric Welding

Type	Group	Number	Mean	SD	t	p
Knowledge of the electric welding technology	Experimental group	61	11.91	2.563	1.275	.047
	Control group	58	11.08	2.710		
Knowledge of electric welding safety	Experimental group	61	12.15	2.455	2.118	.036
	Control group	58	11.20	2.502		

Table 8. Analysis of the Independent Sample t Test on the Learning Effect of the Skills of Electric Welding

Type	Group	Number	Mean	SD	t	p
Electric welding practice	Experimental group	61	69.6213	3.15251	2.148	.035
	Control group	58	66.4621	10.77080		
Total score of the semester	Experimental group	61	79.6089	4.67864	2.143	.032
	Control group	58	76.9707	8.18948		

system. They were provided with diversified teaching stimulation to enhance their interest in learning. In addition, students were encouraged to take the initiative to ask questions, share their ideas, search the knowledge they were curious about, and conduct extensive learning via the system. A student-centered learning environment was created.

(3) Statistical Analysis of the Skills of Electric Welding of the Experimental Group and the Control Group

In terms of the students' learning effect of electric welding skills, this study made an independent sample t test on the average score of the five units of "electric welding practice" and the "total score of the semester". According to the F value of the Levene test, the F value of electric welding practice is .089 ($p=.610>.05$) and the F value of the total score of the semester is .043 ($p=.836>.05$). Neither of the two values is on the significant level, which means that the sample variables of the Experimental Group and the Control Group are homogeneous and that the first column of t values is adopted. As is shown in **Table 8**, the t value of "electric welding practice" is 2.148 ($p=.035<.05$) and the t value of the "total score of the semester" is 2.143 ($p=.032<.05$). The score of the Experimental Group is significantly higher than that of the Control Group.

This study made a further analysis of the scores of the five units of "electric welding practice" of the Experimental Group and the Control Group. As is shown in **Figure 8**, there is stable growth in the scores of electric welding practice of the Experiment. This demonstrated that the Experimental Group have developed interest in the course of electric welding practice and shown a stable growth in the practical skills of electric welding after the Push-pull Course of Special Topic Mobile Learning of Electric Welding. In the contrast, the Control Group shows irregular changes.

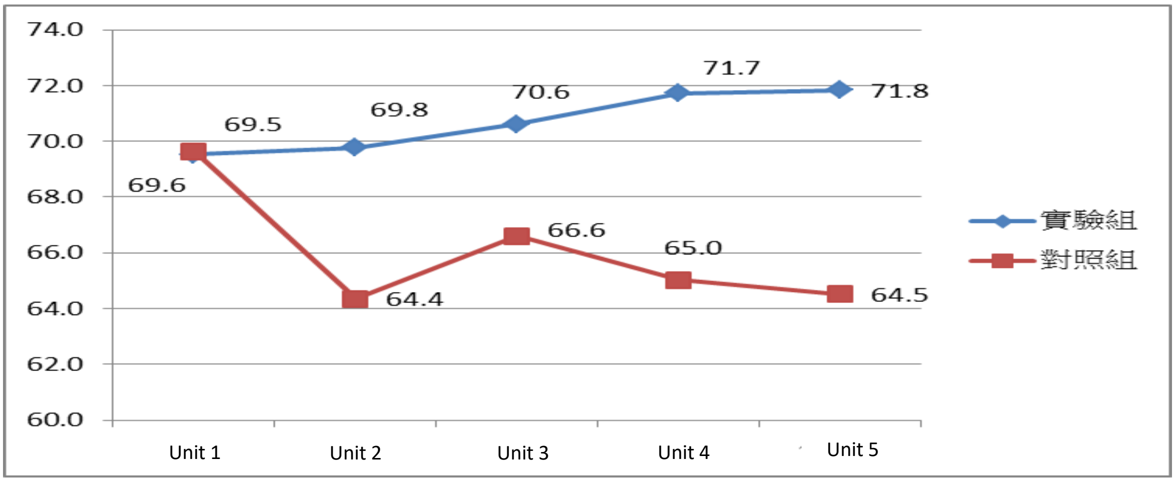

Figure 8. The Line Chart of the Scores of the Five Units of "Electric Welding" of the Two Groups

Based on the above analysis result, after an interview with the teacher, it has been found that, through Push-pull m-learning system, students of the experimental group could catch up with the electric welding course. Via multi-media teaching materials on electric welding, such as pictures or videos, they could prepare lessons before class, refer to the materials at class, and review them after class. Besides, in the activity of creative design of electric welding work, they could use the inquiry, sharing, and discussion functions of Push-pull m-learning system to solve the problems in study and creative design practice so as to realize the goal of "learning while doing". Hence, the academic performance in terms of electric welding skills of students of the experimental group showed stable growth and exceeded that of the control group. In contrary, although students of the control group displayed good overall academic performance at the beginning when they were exposed to the electric welding course due to freshness and enthusiasm, along with the disappear of freshness and the increase of difficulty of course after three to four weeks, their academic performance decreased. It can be seen that the teacher shall pay attention to keep students' interest and enthusiasm in the electric welding course. As of the sudden improvement of homework 3 of the control group, the teacher deemed that it might because the homework was assigned around the mid-term examination. They attached importance to their examination results and changed their learning attitude so as to increase their academic performance. Therefore, it is a strategy for the teacher to set up effective assessment criteria so as to enhance the learning efficiency of electric welding skills of the students.

Analysis of the Learning Attitude towards the Push-pull Course of Special Topic Mobile Learning of Electric Welding

After the experimental instruction, the Experimental Group took the "Self-evaluation Questionnaire of the Learning Attitude towards the Push-pull Course of Special Topic Mobile Learning of Electric Welding", and the results of the survey were used for the single sample t test. As is shown in **Table 9**, the t value of "learning effect" is 10.652; the t value of "learning

Table 9. Analysis of the Single Sample t Test on the Learning Effect of the Course of Electric Welding Practice

Dimension	Number	Mean	SD	Test value = 3	
				t	*p*
Learning effect	61	3.7748	.55396	10.652	.000
Learning behavior	61	3.7118	.51018	10.626	.000
Cooperative learning	61	3.7662	.56372	10.351	.000
The use of the mobile learning system	61	3.3807	.67323	4.307	.000

behavior" is 10.626; the t value of "cooperative learning" is 10.351; the t value of "the use of the mobile learning system" is 4.307. The four dimensions were evaluated with the test value 3, and the means are higher than 3, which indicates a significant difference. This shows that the Experimental Group have been positive in learning effect, learning behavior, cooperative learning, and the use of the mobile learning system after the Push-pull Course of Special Topic Mobile Learning of Electric Welding.

This study made the single sample t test on the items of all dimensions to see the performance of the Experimental Group. The top 3 items on each dimension were discussed as follow:

Here are the top 3 items on the dimension of "learning effect": the "enhanceable practice ability of the course" (with the mean of 4.12 (t=10.169, p<.001)), the "increasable topic-related knowledge of the course" (with the mean of 4.03 (t=11.681, p<.001)), and the "an opportunity of the demonstration of theory and practice in the course" (with the mean of 4.00 (t=10.498, p<.001)). This shows that the Push-pull Course of Special Topic Mobile Learning of Electric Welding can enhance students' learning effect of the course of electric welding practice, offer practical activities related to electric welding, and is popular among students, which is beneficial for students' study of electric welding.

On the dimension of "learning behavior", the highest item is "my learning attitude becomes more positive in the course" (with the mean of 3.89 (t=9.852, p<.001)); the second is "I will apply the skills of exploring special topics to what is new to me" (with the mean of 3.84 (t=9.798, p<.001)); the third is "I will turn to teachers, friends and experts when I encounter problems in the course" (with the mean of 3.71 (t=7.419, p<.001)). This manifests that the Push-pull Course of Special Topic Mobile Learning of Electric Welding can improve the students' learning behaviors in the course of electric welding practice and that the students have become more attentive and active in learning after the course.

On the dimension of "cooperative learning", here are the top 3 items -- "I think that group work is helpful in the learning" (with the mean of 4.03 (t=10.526, p<.001)), "I will try my best to do my work in the group" (with the mean of 4.00 (t=9.327, p<.001)) and "the cooperative learning among groups can enhance interpersonal interaction" (with the mean of 3.94 (t=10.152, p<.001)). This demonstrates that the Push-pull Course of Special Topic Mobile Learning of Electric Welding can accelerate the cooperative learning of students in the course of electric welding practice. It is obvious that an open mobile learning environment can strengthen the interaction and cooperative learning among students and peers.

On the dimension of "mobile learning system", the highest item is "the course assignments motive me to acquire more knowledge of electric welding" (with the mean of 3.58 ($t=5.325$, $p<.001$)); the second is "the course assignments can offer complete topics and directions of learning" (with the mean of 3.51 ($t=4.794$, $p<.001$)); the third is "the course assignments are helpful for the completion of the creative design and making of electric welding products" (with the mean of 3.50 ($t=4.633$, $p<.001$)). The mobile learning system can enhance students' study of the electric welding practice. Specifically, the Push-pull Course of Special Topic Mobile Learning of Electric Welding, which features a systematic curricular design and a diversified learning environment, can guide students in learning according to the curricular progress and equip students with the knowledge and skills of electric welding.

Analysis of the Learning Portfolios of the Push-pull Course of Special Topic Mobile Learning of Electric Welding

In this study, the recording function of the push-pull mobile learning system was used to collect the information about the students' discussions in the making of electric welding products and analyze the students' learning portfolios in the course. Here is an introduction to the conception, making and students' feedback of the electric welding products of the two groups.

(1) Conception: the immediacy of the online discussions in the push-pull mobile learning system can increase the efficiency of group discussions

a. The function of topic discussion is well used to receive all important information

With the function of topic discussion of the push-pull mobile learning system, students can leave message and hold immediate discussions on an irregular basis. For instance, "We saw the products of the elder fellow students in the factor of electric welding practice, and most of the products are chairs and boxes. We want to make something different. (S5-2)"; "In my memory, welding was applied to the wing in the park. (S5-4)"; "It is suggested to design metal tissue boxes and place them in the factory of electric welding practice to exhibit the application of the knowledge taught in the course. Moreover, they are highly practical. (S8-1)". After the group discussions, the students decided on the topic of the creative electric welding products for the group -- mini swing for Group 5 and tissue box for Group 8.

b. The function of immediate response can make group discussions more efficient

The students made use of the immediate response function of the push-pull mobile learning system to discuss the designs of the topic products of their groups, which effectively reduced the time for the development and design of products. For example, "Swings can be seen everywhere and can be drawn with our impression, but different people have different ideas about the cutting, assembly and welding. (S5-1)"; "If the ropes of swings are uneven in

Figure 9. The Finished 3D Picture of S5

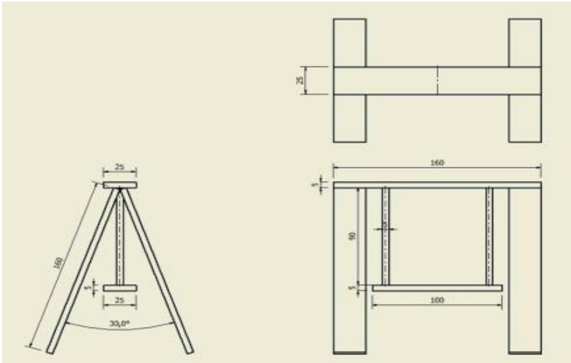

Figure 10. The Material Size Picture of S5

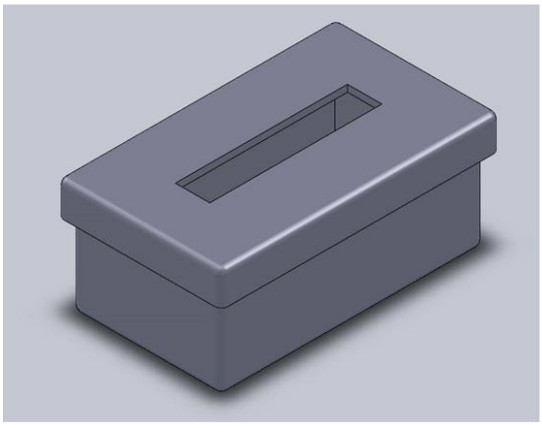

Figure 11. The Finished 3D Picture of S8

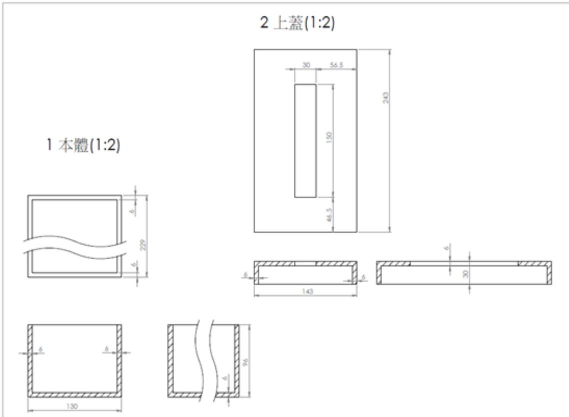

Figure 12. The Material Size Picture of S8

thickness, it would be hard to keep a balance on the swing. (S5-4)"; "To facilitate the refilling of the tissue box, I proposed to design a removable bottom and top. (S8-4)"; "From my perspective, the height of the tissue box should not be excessive, or it would be difficult to get the tissue when it almost runs out. (S8-3)"; "The computer-based drawing skills acquired in the course of 'Computer-based Design' in the last semester can be used to draw 3D pictures and material size pictures. (S5-2); (S8-1)", as is shown in Figures 9 to 12. The instructor should make use of the advantages of the special topic courses to lead students to integrate new and old knowledge and apply it to the practical course of electric welding.

(2) Making: the complete teaching materials of electric welding in the push-pull mobile learning system can enhance the learning effect of electric welding skills

a. The online instruction videos of the course can improve students' learning

In the course, the instructor taught students how to use the oxyacetylene cutting machine so that students could prepare necessary materials according to the design. Meanwhile, the instructor uploaded the instruction videos onto the push-pull mobile learning system to help students with their after-class exercise. "We acquired the oxyacetylene cutting skills according to the instruction videos of the oxyacetylene cutting practice of the push-pull mobile learning

Figure 13. The Material of the Box Bottom of S8

Figure 14. The Material of the Box Cover of S8

Figure 15. The Semi-finished Box Bottom of S8

Figure 16. The Semi-finished Box Cover of S8

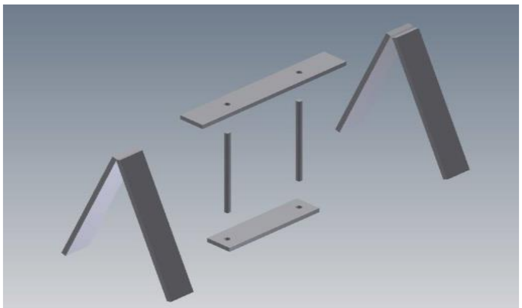

Figure 17. The Drilling and Assembly of S5

Figure 18. The Finished Product Picture of S5

Figure 19. Welded Polish and Grinding

Figure 20. The Finished Product Picture

system and used the high-temperature flame of oxygen and acetylene to melt parts of workpieces and separate the metal workpieces. (S5-4); (S8-2)", as is shown in **Figures 13** and 14. Then, both groups adopted the electric welding skills mastered in the course of Electric Welding to weld and assemble the materials. "We acquired the knowledge and skills of electric welding and use the high temperature of the electricity discharging of arcs to melt the welding bars to connect the workpieces according to the videos. (S8-4)"; "We used electric welding to connect the brackets and top plate on both sides of a swing and reinforce it. (S5-1)", as is shown in **Figures 15** and **16**. Many students applied such devices as drilling machine and grinding machine. "We cut the base and the top plate according to the design and used the drilling machine to drill holes in the base and the top plate for the assembly. (S5-2)", as is shown in **Figures 17** and **18**.

b. Frequent reminder of the knowledge of electric welding safety can help students absorb the knowledge

The instructor used the push-pull mobile learning system to send questions about the knowledge of electric welding safety to students before the course on a regular basis, so that students would follow the rules of safe operation of electric welding practice and prevent the burn caused by the high temperature of welding and the deformation and avoid any cut when electric welding products are ground. "The four legs of a swing should be placed paralleled. Burn and deformation caused by the high temperature in the welding should be prevented. (S5-1)"; "The trimmings of the cut workpieces should be ground to prevent any injury to users. (S5-3)"; "After welding, the cut and welded parts should be ground to prevent injuries. (S8-1)", as is shown in **Figures 19** and **20**. All the students completed the creative electric welding products on time under the guidance of the instructor.

(3) Students' response: The convenience of the push-pull mobile learning system can enhance the cooperative learning of students

a. The convenience of mobile learning can help students master the skills of electric welding

After the Push-pull Course of Special Topic Mobile Learning of Electric Welding, most students the convenience of the push-pull mobile learning can facilitate students' acquisition of electric welding skills and improve their learning. "In the past, I thought it difficult to master electric welding skills. But the instruction videos in the mobile learning system enabled me to acquire the skills within a short time. (S5-2)"; "The instruction videos showed me that electric welding was not as difficult as I expected. Moreover, I mastered the skills of cutting in the course. (S8-2)".

b. The interaction of mobile learning helps students develop a positive learning attitude

In the Push-pull Course of Special Topic Mobile Learning of Electric Welding, the instructor's guidance and the discussions and knowledge sharing among the peers helped students develop a positive learning attitude. "A mini swing is seemingly simple, but attention must be paid to all steps in the making. The materials must be cut precisely to prevent any waste. (S5-1)"; "The design and making of a product involves many steps, even if it is a tissue box. (S8-1)".

c. The maneuverability of mobile learning can enhance the cooperative learning of students

In the push-pull mobile learning system, students were willing to discuss questions on the system platform, which made their cooperative learning more efficient. "The push-pull mobile learning system enabled us to give full play to our teamwork spirit. Some of us focused on cold work and some on drawing. The rational labor division enables all of us to make contribution to the work. (S5-4)"; "We had a great time in the discussions in the push-pull mobile learning system. All of us have different strengths in different fields, and the labor division made our work relaxing. (S8-3)".

CONCLUSION AND SUGGESTIONS

According to the above research results and discussions, this study has come to the following conclusions and suggestions:

Conclusion

After the 15-week experimental instruction, the questionnaire and written information about the students were analyzed and discussed, which has led to the following conclusions:

1. The Push-pull Course of Special Topic Mobile Learning of Electric Welding consists of three parts - instruction, learning and multi-dimensional evaluation

This study applied the concept of "mobile learning" to the special topic-based course of electric welding in a university of science and technology and develop the Push-pull Course of Special Topic Mobile Learning of Electric Welding, which includes three parts -- (1) the instruction of the electric welding course, (2) the learning of the electric welding course, and (3) the multi-dimensional evaluation of the electric welding course. With the help of the push-pull mobile learning system, students will have a more diversified channel of studying electric welding in the traditional course of electric welding practice. The course enables students to acquire and apply the knowledge and skills of electric welding in a more efficient way (Chung, Dzan, Shih & Lou, 2015).

2. The Push-pull Course of Special Topic Mobile Learning of Electric Welding can significantly enhance the students' learning effects of electric welding

The Experimental Group got a higher score in the post-test than in the pre-test in the learning effect of the "knowledge of electric welding" after the course. Moreover, the Experimental Group had greater learning effects of the "knowledge of electric welding" and the "skill of electric welding" than that of the Control Group after the course. Specifically, the instruction strategies of the course can significantly promote the students' learning effects in the acquisition of the knowledge and skills of electric welding.

3. The students show a positive learning attitude towards the Push-pull Course of Special Topic Mobile Learning of Electric Welding

After the course, the Experimental Group made positive remarks on the four dimensions -- (1) learning effect, (2) learning behavior, (3) cooperative learning and (4) mobile learning in the self-evaluation scale of the attitude towards the course of electric welding. In short, most the students made a positive assessment in the general self-evaluation of the learning attitude towards the course (Wu & Pemg, 2016).

4. The course can increase the efficiency of discussions among students and enhance the learning of electric welding skills and cooperative learning

According to the analysis of the students' learning portfolios in the Push-pull Course of Special Topic Mobile Learning of Electric Welding, it is found that the system offers immediate bilateral interaction which can enhance the efficiency of group discussions. Moreover, the instructor can make full use of the functions of the system, including the multi-media teaching materials, the uploading of archives and browsing, to provide students with diverse learning methods and enhance their learning effects. The convenient use of the system makes students willing to adopt the system for discussion and learning, which effectively reinforces the effects of cooperative learning (Lou, Cheng & Kuo, 2015).

Suggestions

According to the above research results, this study gives the following suggestions:

1. Schools should incorporate the Push-pull Course of Special Topic Mobile Learning of Electric Welding into the planning of the course of electric welding practice

This study shows that the Push-pull Course of Special Topic Mobile Learning of Electric Welding could significantly improve the students' learning effects of electric welding and that most of the students accepted the instruction model. Additionally, the course consists of (1) the instruction of the electric welding course, (2) the learning of the electric welding course, and (3) the multi-dimensional evaluation of the electric welding course, which can satisfy the requirements of the planning of the electric welding course. Hence, it is suggested that schools incorporate the Push-pull Course of Special Topic Mobile Learning of Electric Welding into the planning of the course of electric welding practice and well plan the orientation and application of the course, so as to create a diversified learning environment for students.

2. The instructor should add the Push-pull Course of Special Topic Mobile Learning of Electric Welding to the curricular design of the course of electric welding practice

This study shows that most students had a positive attitude towards the Push-pull Course of Special Topic Mobile Learning of Electric Welding. It also revealed that most students made positive remarks on the systematic instruction design of the course and its role in the learning effect, learning behavior and cooperative learning among students and in the use of the mobile learning system. Therefore, the instructor should combine the Push-pull Course of Special Topic Mobile Learning of Electric Welding with the instruction design of the course of electric welding practice and apply the multi-functional mobile learning system to provide students with a planned learning schedule and design the instruction that meet personal needs.

3. Suggestion for the instructional implementation of the Push-pull Course of Special Topic Mobile Learning of Electric Welding

Most of the students made a positive assessment of the Push-pull Course of Special Topic Mobile Learning of Electric Welding after the course, which shows that college students are interested in a diversified mobile learning environment; hence, instructors should be encouraged to use the course to support their instruction of electric welding. According to the analysis of the experimental instruction portfolios and the instruction focuses of the course, this study gives these suggestions: (1) the convenience of the immediate discussions of the mobile learning system needs to be highlighted so that students will be able to have immediate discussions at any time and at any place; (2) the function of uploading pictures and videos of the mobile learning system should be well applied to establish a complete curricular database and the information should be delivered to students according to the progress of the instruction, so as to enhance students' learning effects; (3) the mobile learning system and the design of the electric welding course should be integrated so that students will be able to focus on learning effects, which will promote the effects of cooperative learning. Meanwhile, instructors can adopt the system to collect the information about the learning progress and effects of students and take it as an important basis for the adjustment of the instruction content and progress.

4. Future prospects of m-learning

With the maturity of mobile devices, m-learning becomes a growing trend. Its learning outcomes had been confirmed by many studies. And it becomes one of the important ways of learning nowadays. However, via developing “Push-pull M-learning Course of Electric Welding", this study has found that m-learning materials on a specific topic are customized, so their production cost is high, resulting in the limits of promotion of m-learning. Therefore, it suggests that R&D personnel of the digital industry can develop simple and easy to use tools as developing tools for m-learning materials to facilitate teachers to transfer the existing learning content to mobile devices, to provide a more convenient and better m-learning environment for students.

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