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An Integrated BIM and cost estimating blended learning model – acceptance differences between experts and novice

Yun-Wu Wu, Ming-Hui Wen, Ching-Ming Chen & I-Ting Hsu
China University of Technology, TAIWAN

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"Building information technology" and "cost estimating" are two core skills of construction education. However, in traditional education, students learn these two important subjects in separate courses. This study proposes a blended learning environment which can provide students with support for their face-to-face learning activities in the classroom and also give them the opportunity of "learning by doing" through their practice with online construction projects in the web-based BIM (building information modeling) & cost estimating system. Then the TAM3 (Technology Acceptance Model 3) theory was used to compare the expert and novice students' acceptance of this blended learning model. Finally, the path analysis method was used to verify the research hypotheses developed in this study based on the TAM3 method and then further explore the cause-effect among the TAM3 variables in these hypotheses. Our result found that the blended learning environment developed in this study was generally accepted by all the participating students and it could also enhance the students' acceptance of the blending learning strategy that combines classroom-based education and on-line learning. Even though there are significant differences between novices and experts in certain variables as found in this study, students can still achieve desirable learning results through repeated and continuous practice and learn how to solve problems through "learning by doing" and discussions with their peers inside and outside the classroom. As a consequence, they will have better learning results in the end.

Keywords: concept transformation learning model; creativity; learning process; experts and novices

INTRODUCTION

The construction industry is a knowledge-intensive industry (Rodgers et al.,

Correspondence: Ching-Ming Chen,
Department of Architecture, China University of Technology, No. 56 Sec. 3, Singlong Rd., Taipei 116, Taiwan.
E-mail: cmchen@cute.edu.tw

2001) characterized with a fragmented knowledge framework (Kamara et al., 2002). Therefore, if without suitable teaching strategies, students in construction or
engineering education tend to learn fragmented knowledge without effective establishment of their own cognitive structures. Therefore, how to enable students to effectively and systematically learn and develop their cognitive structures about the construction industry is a research-worthy topic.

"Architectural design specifications" and "cost estimating" are the core business of the construction industry. The professionalism represented in the design specifications is a decisive factor for the quality of the architectural design while the precision of the cost estimating can decide the success or failure of a construction project. However, in traditional education, students learn these two important subjects in separate courses. For example, in the courses about design specifications, students only learn the basic knowledge about the relevant computer system and its commands in the computer lab without learning any knowledge of an actual construction project. Because of this kind of fragmented (or partial) learning, students do not know how to relate and apply their knowledge about the computer system in real-life construction projects and, as a result, feel unmotivated in their learning.

In the courses about construction project cost estimating, students learn how to assess the costs by obtaining quantity and unit price information about the required materials, facilities, equipment, and construction methods. However, their learning of cost estimating is limited in both time and space (only in the classroom during the course hours) and their learning is also not conducted in real-life contexts. In terms of course contents, students can only learn fragmented knowledge about material characteristics and basic specifications; therefore, they do not know how to effectively use the knowledge they acquired from the courses in actual cases.

State of the literature

- Building information modeling (BIM) system is a digital tool that developed for architecture and civil engineering. The use of BIM can help to reduce the time required for cost estimating of a building and construction project.
- Problem-based learning (PBL) is a teaching strategy intended to cultivate students' learning attitude to use the knowledge they have learned in handling and solving problems in real-life situations.
- Blended learning (BL) is a teaching strategy that combines multimedia and traditional face-to-face learning in the classroom. The BL can help students to convert from passive learning to active learning and overcome the problems of low motivation for course completion and low satisfaction.

Contribution of this paper to the literature

- The study develops a BIM & cost estimating blended learning (BL) environment based on the PBL strategy can provide all the required resources for the guidance of students in their learning process.
- Through the web-based BIM & cost-estimating system developed in this study, students can practice cost estimating anytime and anywhere so that they can properly build their own schemas about construction project cost estimating.
- The blended learning environment developed in this study was generally accepted by all the participating students and were expected to help the student to develop both "building information technology" and "cost estimating", the two core skills of construction education.

The rapid development of ICT technologies has brought forth diversified methods of teaching and learning. In addition to "face-to-face" learning from teachers in the classroom, students can also learn about real-life construction projects through project simulation in virtual and digital environments any-time and anywhere. Through their practice with virtual construction projects, students can learn more effectively about architectural design specifications and cost estimating through their hand-on operation (Messner et al, 2003).

To verify if project-based learning (PBL) can really help students to develop their knowledge structures and core capabilities regarding the construction industry, the teaching strategy of project-based learning is used in this study while a blended BIM & cost estimating project-based learning model is developed in this study that integrates learning in the classroom and learning in the web-based virtual environment (a digital learning system about BIM and cost estimating established in this study). The so-called BIM (building information modeling) refers to the use of 3D models of business information to visualize the equipment/facility management in the building, help the user to keep track of the progress of the maintenance/management of a construction project, and achieve cost estimating for a construction project (Chien, Wu & Huang, 2014; Meža, Turk & Dolenc, 2014).

The blended learning environment established in this study can provide students with support for their learning in the classroom and also give them the opportunity of "learning by doing" through their practice with virtual construction projects in the web-based BIM & cost estimating system. In addition, the students can have discussions with their peers in the classroom, which can promote better teaching performance (Murnane & Phillips, 1981). Through this method of interactive learning and teaching, students can apply what they learn from the courses about BIM and cost estimating in their operation in real-life cases. Through repetitive practice, the students can easily achieve continuous learning and obtain desirable learning results from the blended learning.

In the following sections of this paper, the second section is a literature review of BIM, cost estimating, project-based learning (PBL), blended learning and technology acceptance model 3 (TAM3). The third section describes the teaching experiment in this study using the integrated BIM & cost estimating blended learning model based on the teaching strategy of PBL. In the final section, the TAM3 scale is used in the questionnaire survey on the participating students in the experiment and the questionnaire results are statistically analyzed to find out the learning results of the students and the learning differences between expert students and novice students in the blended learning environment.

LITERATURE REVIEW

Building Information Modeling (BIM)

BIM is a digital tool recently developed for architecture and civil engineering (Cheung et al, 2012; Love et al, 2014). It can be used in different stages of the life cycle of a building from its design, construction, and operation to maintenance (Love et al, 2013). With BIM, the management of a building and its equipment/facilities can be visualized through 3D modeling of the building's information, allowing the project manager to have better understanding of the maintenance/management progress of the construction project. Through BIM, different kinds of graphic and non-graphic data can be provided to the architect, engineers and project owner so that they can have better cost estimating of the project, improve project management quality and efficiency, and make required decisions throughout the whole lifecycle of the building.

BIM has been used to integrate the building information and cost management in different lifecycle stages of a building starting from design, construction to maintenance (Kehily, Woods & McDonnell, 2013) Since BIM can automatically produce quantity information about materials and equipment components of the building, comprehensive cost estimating of the construction project can be implemented by combing the quantity information with the unit price and specification information of the materials and components already stored in the database (Lee, Kim, & Yu, 2014). In addition, BIM is capable of directly extracting and editing data from Revit MEP into documents respectively for the project owner, purchasing personnel, designers, and construction engineers according to their different requirements. Therefore, it can save a lot of time for document preparation and production. Last but not least, BIM is also capable of producing all at once the floor plans, vertical plans, perspective drawings and the other graphics of the architectural structure as well as all the riser diagrams, system diagrams, de-tail drawings and the other graphics of the facilities/equipment. Therefore, it can prevent the requirement of extra working time for overlapped production of design specification drawings (Park et al, 2011; Ding, Zhou & Akinci, 2014).

The teaching of BIM in the classroom can only teach students about its basic concepts and commands at most. Even though students can answer questions about the BIM system correctly in the exams, they still have difficulties in using their knowledge about BIM in actual operation. Therefore, using the strategy of project-based learning, this study is intended to enable the students to obtain experiences of using their BIM knowledge through their operation in an authentic case and then develop their professional abilities.

Construction project cost estimating

The cost estimating of a construction project is intended to provide assistance for the budget planning, cost-benefit analysis, and feasibility assessment of the construction project. It covers the conceptualization, planning, design, contracting, construction, and turnkey use of a building. The owner, designer and construction party of a construction project each has their own cost control target. Therefore, it is very important to have good cost estimating of each stage of the project to ensure sufficient capital turnover throughout the project. Good cost control depends on good budget planning while good budget planning depends on good cost estimating.

Cost estimating of a construction project requires gradual information accumulation of the project. There are different types of cost-estimating methods according to their precision levels: rough estimating, conceptual estimating, and detailed estimating. Each type of method is suitable for different stages of a construction project to produce reasonable cost estimates. In the traditional process of cost-estimating, a lot of time is spent in obtaining the specification and quantity information from the drawings and then in calculating the total costs. It is time-consuming and inefficient. The use of BIM can help to reduce the time required for cost estimating (Shen & Issa, 2010). Since cost estimating is often implemented within a short period of time while the estimating results must be precise enough to convince the project owner and the designer, it is very important to have a suitable system or method to help with the work of cost estimating (Sonmez, 2004). In the classroom, students can only learn some basic knowledge about cost estimating within limited time without any thorough or repetitive practice for it takes a lot of time to calculate the costs. Through the web-based BIM & cost-estimating sys-tem developed in this study, students can practice cost estimating anytime and anywhere so that they can properly build their own schemas about construction project cost estimating.

Project-Based Learning (PBL)

PBL is a teaching strategy intended to cultivate students' learning attitude to use the knowledge they have learned in handling and solving problems in reallife situations. According to this strategy, student-centered learning activities about real-world issues are designed for students. In these activities, students divided into different groups are required to solve a problem or complete a task using the knowledge they have learned in the classroom (San-Segundo, 2005; Macías-Guarasa, 2006) instead of using the knowledge to answer questions in the exams only. Answering questions in the exams correctly is not the major purpose of education and will not fulfill the professional requirements at work in the future. The BIM & cost estimating blended learning environment established in this study based on the PBL strategy can provide all the required resources for the guidance of students in their learning process (Luis, Mellado & Díaz, 2013). Divided into groups, the students are required to implement the BIM and cost estimating of a real-life construction project in the web-based virtual environment so that they can work together and learn how to solve authentic problems of the project anytime and anywhere (Blumenfeld , 1991; Efstratia, 2014). If they encounter any problem in their implementation of the task, they can raise the problem in the class-room for brainstorming to find out the solution.

Blended learning (BL)

BL is a teaching strategy that combines ICT and traditional face-to-face learning in the classroom (Owston, York, & Murtha, 2013; Chiang & Wang, 2015). It can help students to convert from passive learning to active learning (Drysdale et al, 2013) and overcome the problems of low motivation for course completion and low satisfaction. According to existing research, the BL strategy can enable students to have better learning performance than either fully face-to-face learning or fully on-line learning (Yeh, Huang & Yeh, 2011).

In this study, the students can learn knowledge about BIM and cost estimating in the classroom while they can also learn the knowledge in the web-based blended learning environment. In addition, they also have to work in groups to complete the as-signed task through online meetings and discussions (Shih, 2013). According to the PBL strategy, the students in this study are divided into groups and asked to implement with their group members the BIM and cost estimating operation of an actual construction case so that they can learn from doing. The students can discuss about the task in the classroom and also in the virtual learning environment developed in the study. If they encounter any problem in their task implementation, they can raise the problem in the classroom for brainstorming. The BL method can combine the benefits of face-to-face learning and on-line learning, motivating students to proactively learn and seek solutions to their problems (Shih, 2012). Through their proactive learning and instructional relation-ships such as mutual discussion and cooperation, students can receive suggestions on their learning, start to have self-reflection and analysis of how to improve and consequently achieve better learning results.

Technology Acceptance Model 3 (TAM3)

The technology acceptance model (TAM) was pro-posed by Davis in 1986 based on the theory of reasoned action (TRA) and theory of planned behavior (TPB). It can be used to explore factors influencing users' acceptance of an information technology (Davis, 1986). According to TAM, there are mainly two dimensions of factors influencing users' intention to use a technology or system: perceived usefulness (PU) and perceived ease of use (PEOU) of the technology/system (Davis, 1986). The factors of these two dimensions have an influence on the users' attitudes towards using and behavioral intention to use the technology/system (Venkatesh et al, 2003).

In 2008, Venkatesh and Bala (Venkatesh, 2008) proposed TAM3, which not only defines the external factors that can influence users' perceived usefulness not included in TAM or TAM2. These factors can be divided into two dimensions: anchor and system adjustment.

The factors of the anchor dimension are (1) computer self-efficacy: the degree to which a user believes that he/she has the ability to perform specific task using computers; (2) perception of external control: the same as the definition of facilitating conditions; (3) computer anxiety: the degree of a user's apprehension or fear when facing with the possibility of using computers; and (4) computer playfulness: the degree of a user's cognitive spontaneity in microcomputer interactions. The factors of the adjustment dimension are: (1) perceived enjoyment: the degree to which the activity of using a specific system is perceived by a user to be enjoyable, not including any performance consequences resulting from the system use; and (2) objective usability: a comparison by a user of systems based on the actual level (rather than perceptions) of effort required to complete specific tasks.

TAM3 predicts the application or use of an information technology mainly from the personal perspectives of users. According to Venkatesh & Davis (Venkatesh & Davis, 2000), perceived ease of use is significantly correlated with the users' control (including computer self-efficacy and facilitating conditions), internal motivation (computer playfulness) and emotions (computer anxiety). The computer self-efficacy has an influence on the user's expectation of the consequences resulting from the use of the computer (Compeau & Higgins, 1995).

In addition, the computer self-efficacy is the major variant for the prediction of computer use and also a major decisive factor for a user in his or her decision to use an information technology/system. According to some empirical evidence, the application of TAM is correlated with the user's computer competence and knowledge, which is also the basis for the user to determine if a new technology or system is easy to use. Therefore, it is important to find out if a user feels uncertain, anxious, helpless or intimidated (i.e. suffering from computer anxiety) when facing the possibility of using a computer due to his/her low computer self-efficacy (Venkatesh et al, 2003).

Different from TAM and TAM2 that predict users' acceptance of a technology/system based on users' subjective perceptions, TAM3 also explores the objective usability and perceived enjoyment of a technology/system as a user continues using the technology/system over time and accumulates experiences. The objective usability of a technology/system can be verified and evaluated through experiments. In other words, both subjective and objective analysis methods are used in TAM3 to evaluate the users' acceptance of a technology/system. In this Internet era with continuously evolving information technologies, the technology acceptance model has also been continuously evolving from TAM, TAM 2 to TAM 3 as well to enhance the completeness of the TAM theory and provide maximum explanation and pre-diction of the use of Internet technologies.

Expert and novice

Experts and novices are not different in their cognitive capabilities but in their application of knowledge in their memories to solve a problem. According to existing research, the process of attention application is of great importance for people in their problem-solving process (Di et al, 2007). Experts and novices are mainly different in the schemas they use to solve problems in their professional fields (Glaser, Chi & Farr, 1988). In addition, the schemas of experts involve a large quantity of highly connected knowledge units organized according to their structural similarity. By contrast, the schemas of novices involve a relatively small quantity of less connected knowledge units organized according to their superficial similarity (Bryson & Levit, 1991). Novices and experts are also different in their problem-solving methods. Novices spend time mostly on different dimensions of the problem and on the connections between the problem-solving strategy and the final solution. Experts spend most of their time analyzing the symptoms of the problem and spend less time than novices in implementing the problem-solving strategy (Lesgold, 1988). Experts are capable of turning their problem-solving operation into intuitive operation through two steps: (1) adding new schemas developed from solving the problem into their already highly developed and organized schemas; and (2) developing intuitive responses to problems similar to the current problem.

Through these two steps, experts can transfer the cognitive load of problem solving from limited working memories to unlimited long-term memories so that their problem solving become more effective and accurate. By contrast, novices use their working memories to retain different information about the problem and all the possible problem-solving strategies. When encountering completely new problems, experts are more likely to solve the problems better than novices due to their better developed schemas and better self-monitoring capabilities (Lesgold, 1988).

DESIGN AND EVALUATION OF THE INTEGRATED BIM AND COST ESTIMATING BLENDED LEARNING MODEL

Blended learning model

In the integrated BIM and cost estimating blended learning system developed in this study, the students were required to take the two courses respectively of BIM and cost estimating in the classroom. They were divided into groups and given a real-life case to operate in the web-based hybrid BIM & cost estimating system developed in this study. Through their learning in the classroom and their practice in the web-based system, the students could learn related professional knowledge and skills from doing. Then the TAM3 theory was used in this study to compare the learning differences between learners with different backgrounds (novices and experts). The structure of the blended learning strategy used in this study is illustrated as follows in Figure 1.

Web-based hybrid BIM & cost estimating system and learning activities

The cost estimating of a construction project requires gradual accumulation of information of the project. In addition, different cost estimating methods are used in different stages to ensure reasonable cost estimating results with acceptable error values. In this study, the BIM data of the components for the simulated project used for the students' practice were first introduced into the web-based BIM & cost estimating system developed in this study. This system was capable of estimating all the related costs of the project quickly and precisely. In addition, through the Internet, multiple users could practice and operate on the same BIM and cost estimating task in this system. The system was based on PHP with the MySQL open-source database software running on the Apache proxy server. The interfaces were dis-played in the form of webpages. The input data were transmitted through the ODBC database to the PHP system for computation and implementation.

The students in this study were first divided into groups and then given a real-life construction project for them to practice the BIM and cost estimating of the project

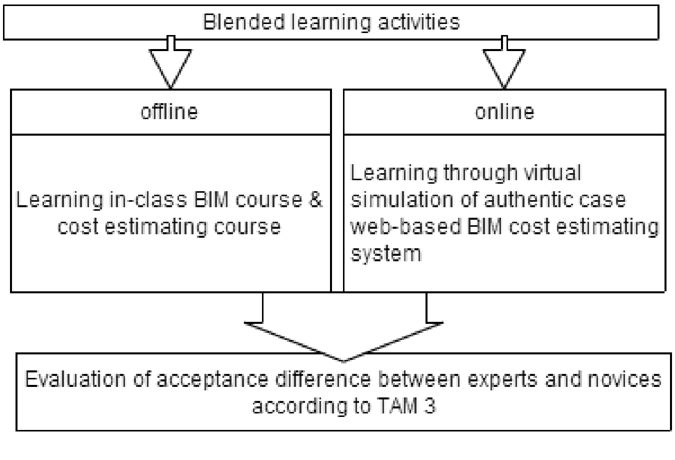

Figure 1. Integrated BIM and cost estimating blended learning model

in groups using the web-based BIM & cost estimating system according to the following steps illustrated in Figure 2—step1: build a 3D BIM model; step2: develop

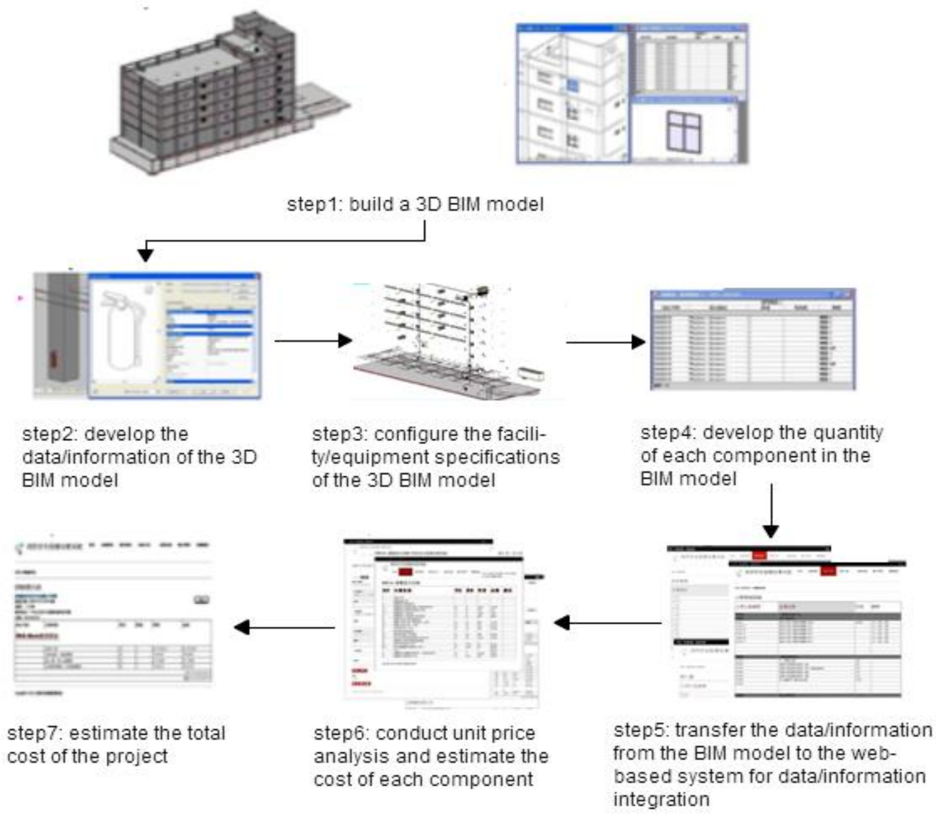

Figure 2. Web-based cost estimating system with project-based learning activities

the data/information of the 3D BIM model; step3: configure the facility/equipment specifications of the 3D BIM model; step4: develop the quantity of each component in the BIM model; step5: transfer the data/information from the BIM model to the web-based system for data/information integration; step6: conduct unit price analysis and estimate the cost of each component; and step7: estimate the total cost of the project. If they had any problem or question in their practice, they could ask the teacher or raised it in class for brainstorming and discussions to find out the solution. From this kind of "learning through doing", the students could develop their professional knowledge and skills.

Experiment design

Participants

After the students' blended learning, a questionnaire survey based on the TAM3 theory framework was conducted on the students and the experts who also used the system. The questionnaire results were statistically analyzed to explore the experts' and novices' intentions to use the web-based BIM & cost estimating system developed in this study. The participants in this study were 32 experts and 42 novices. The experts were people with more than three years of working experiences in the industry and also with the professional capability of cost estimating and design drawing production for construction projects. The novices were senior students of a department of architectural design at a university in

Taiwan and these students had completed and obtained credits of the courses about project cost estimating and BIM design.

Variables & Hypotheses

Based on the TAM3 theory framework and relevant literature, this study proposed the following hypotheses of the cause-effect relationships among the dimensions of "job relevance", "output quality", "result demonstrability", "computer self-efficacy", "computer anxiety", "perceived usefulness", "perceived usefulness", "perceived ease of use" and "intention to use" as illustrated in Figure 3.

The relevance of the BIM & cost-estimating system developed in this study to what the students learned in class and what they were asked to do in the task would directly influence their perceived usefulness of the system. Therefore, this study proposed "H1: Job relevance has a positive influence on perceived usefulness."

Moreover, the accuracy of the contents provided by the system and its input/output consistency could directly affect the students' use of the system, efficiency of implementing the project simulation using this system, and their satisfaction with the system. In other words, the two factors of output quality and result demonstrability could affect the students' perceived usefulness of the system. Therefore, this study proposed "H2: Output quality has a positive influence on perceived usefulness"; and H3: Result demonstrability has a positive influence on perceived usefulness."

According to the TAM3 theory, there are two external factors: "computer self-efficacy" and "computer anxiety" that can affect the perceived ease of use while there are differences between novices and experts in their background knowledge and their computer competence. Therefore, this study proposed H4: Computer self-efficacy has a positive influence on perceived ease of use; and H5: Computer anxiety has a negative influence on perceived ease of use.

Finally, the participating students' willingness or intention to continue using the system could be influenced by their perceived usefulness and perceived ease of use of this system. In addition, their computer competence levels (i.e. perceived ease of use of the system) could influence their perceived useful-ness of this system as well. Therefore, this study proposed H6: Perceived ease of use has a positive influence on perceived usefulness; H7: Perceived usefulness has a positive influence on the users' intention to use the system, and H8: Perceived ease of use has a positive influence on the users' intention to use the system. A path analysis was conducted (see Figure

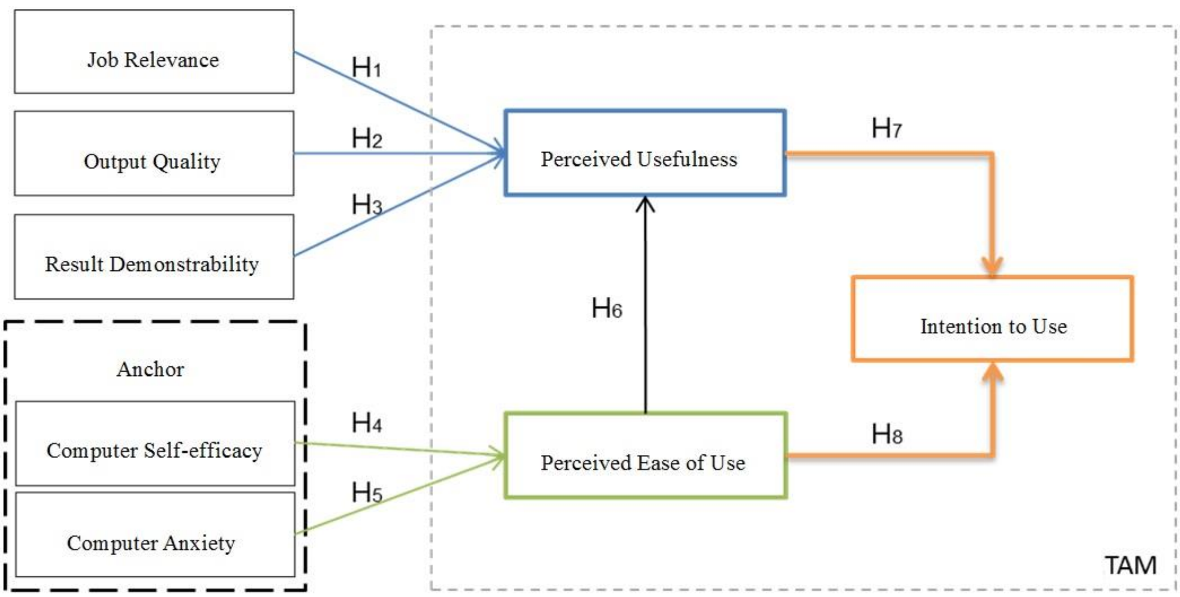

Figure 3. TAM3-based research framework and hypotheses of this study

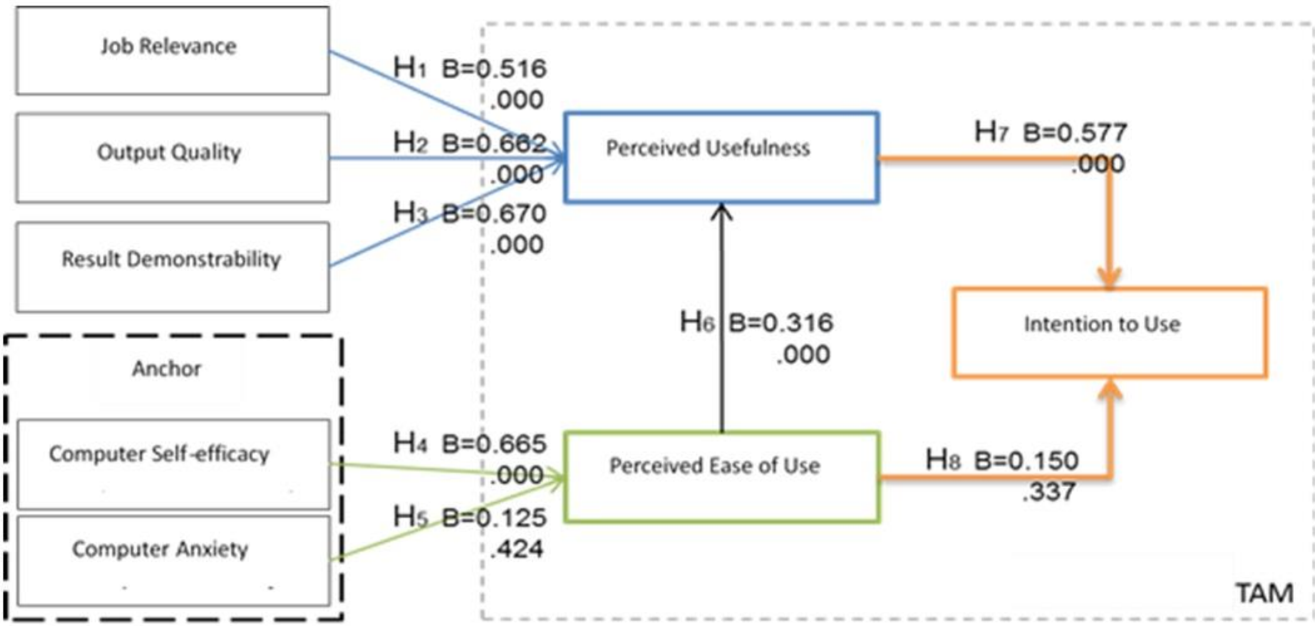

Figure 4. Path analysis verification of H1 to H8 in this study

4) to verify each of the eight hypotheses developed in this study.

RESULTS

Reliability analysis

The questionnaire was composed of questions regarding the seven dimensions of "intention to use", "perceived usefulness", "perceived ease of use", "job relevance", "output quality", "result demonstrability", "computer self-efficacy" and "computer anxiety". The Likert's 5–point scale (1 point: strong disagreement; 2 points: disagreement; 3 points: no comment; 4 points: agreement; and 5 points: strong agreement) was used to measure the subjective perceptions of the subjects. According to the reliability analysis results, the Cronbach's α coefficients of all the dimensions in the questionnaire (0.735~0.949) were all larger 0.7, indicating good consistency and reliability of all the dimensions in this questionnaire. In addition, the questions in the questionnaire were all based on references from existing research to ensure good validity of the questions. The reliability analysis results of the dimensions in the questionnaire are shown in Appendix A.

Differences between the experts and novices

To find out if there is any significant difference be-tween the experts and novices in this study in their intention to use, perceived usefulness, perceived ease of use, job relevance, output quality, result demonstrability, computer self-efficacy and computer anxiety. An independent sample t-test was conducted.

According to the t-test analysis results shown in Table 1, there was a significant different between the experts and novices respectively in their "intention to use" ($t(72) = -2.135$, $p < 0.05$), "perceived ease of use" ($t(72) = -2.953$, $p < 0.01$", and "computer anxiety" ($t(72) = -2.085$, $p < 0.05$). In addition, the experts had higher "intention to use" the system and higher "perceived ease of use" of the system than the novice. This finding indicated that the experts believed this system was worthy of learning and they were more willing to continue using this system than the novices. In addition, they found the system easier to use and felt less anxiety when using it than the novices.

Finally, in all the dimensions other than "computer anxiety", the average scores of both the experts and novices were all higher than 3 points. This finding indicated that both the experts and novices generally recognized the benefits brought by the web-based BIM & cost estimating system developed in this study.

Path analysis results

In the path analysis of this study, five sets of multiple regression analyses were conducted to verify the H1~H8 of this study. According to the analysis results, all the first seven hypotheses reached the level of significance except for "H8: Perceived ease of use of the system has a positive influence on the users' intention to use this system." The overall verification results of the hypotheses through the path analysis are shown in Table 2. The following is a further discussion of the path analysis results of each hypothesis.

According to the results shown in Table 3, the three variables in H1 (job relevance), H2(output quality) and H3(result demonstrability) each has a positive influence on perceived usefulness ($p < 0.05$) with a R^2 value of 0.454, indicating job relevance, output quality and result demonstrability can explain 45.4% of the users' use of the web-based BIM & cost estimating system. In other others, job relevance, output quality and result demonstrability have a positive influence on the users' perceived usefulness of the system. The significant influence of job relevance on the users' perceived usefulness of the system indicated that the users believed this system could provide effective and relevant assistance for their jobs. The significant

Table 1. Analysis results of the expert-novice differences in each dimension

Dimension	Novice (n=42)		Expert (n=32)		t	P
	Average	SD	Average	SD		
Intention to Use	3.63	.518	4.15	.335	-2.135	.039
Perceived Usefulness	3.65	.576	3.85	.627	-1.413	.165
Perceived Ease of Use	3.07	.544	3.85	.627	-2.953	.005
Job Relevance	3.61	.556	3.8	.447	-.715	.479
Output Quality	3.51	.641	3.6	.651	-.284	.778
Result Demonstrability	3.51	.641	3.5	.612	.043	.966
Computer Self-efficacy	3.19	.524	3.51	.278	-1.325	.193
Computer Anxiety	2.69	.242	2.4	.583	2.085	.043

Table 2. Verification results of the hypotheses

c	Significance
H_1: Job relevance has a positive influence on perceived usefulness.	Yes
H_2: Output quality has a positive influence on perceived usefulness.	Yes
H_3: Result demonstrability has a positive influence on perceived usefulness.	Yes
H_4: Computer self-efficacy has a positive influence on perceived ease of use.	Yes
H_5: Computer anxiety has a negative influence on perceived ease of use.	Yes
H_6: Perceived ease of use has a positive influence on perceived usefulness.	Yes
H_7: Perceived usefulness has a positive influence on intention to use.	Yes
H_8: Perceived ease of use has a positive influence on intention to use.	No

Table 3. Path analysis results of H1, H2 and H3

Dependent Var.	Independent Var.	Standardized beta	t	P	VIF
Perceived Usefulness	Job Relevance	0.516	3.856	0.000	1.000
	Output Quality	0.662	5.654	0.000	1.000
	Result Demonstrability	0.670	5.774	0.000	1.000

R^2=0.454 F=31.970 *P<0.001*

influence of output quality on the users' perceived usefulness indicated the users believed the output quality of the system's structure, functions and webpages was high and satisfactory. The significant influence of result demonstrability on the users' perceived usefulness of the system indicated the users believed the results shown in the system easy to understand and share with others. The three findings are consistent with those in the research conducted by (Venkatesh & Davis, 2000).

Both "H4: Computer self-efficacy has a positive influence on perceived ease of use" and "H5: Computer anxiety has a negative influence on perceived ease of use" reached the level of significance, indicating these two hypotheses were supported. This finding is consistent with those of existing research (Venkatesh & Davis, 2000). In addition, with H5 supported, it means the higher anxiety the users feel when using the system developed in this study, the more likely they will have negative perceptions about the system's ease of use. The path analysis results of H4 and H5 are shown in Table 4 as follows:

According to the path analysis results, "H6: Perceived ease of use has a positive influence on perceived usefulness" reached the level of significance ($p < 0.05$), indicating the users' perceived ease of use of the system indeed had a positive influence on their perceived usefulness of the system. This finding is consistent with that of the research by Venkatesh & Bala in 2008.

"H7: Perceived usefulness has a positive influence on intention to use" reached the level of significance according to the path analysis results ($p < 0.05$), meaning this hypothesis was supported and the users' perceived usefulness of the system developed in this study indeed had a positive influence on their intention to use the system.

The connections between the two variables in "H8: Perceived ease of use has a positive on intention to use" did not reach the level of significance ($p = 0.337$), indicating that the users' intention to use the web-based BIM & cost estimating

Table 4. Path analysis results of H4 and H5

Dependent Var.	Independent Var.	Standardized beta	t	P	VIF
Perceived Ease of Use	Computer Self-efficacy	0.665	5.703	0.000	1.000
	Computer Anxiety	0.125	0.807	0.000	1.000

R2=0.256 F=10.651 *P<0.001*

Table 5. Path analysis results of H6

Dependent Var.	Independent Var.	Standardized beta	t	P	VIF
Perceived Ease of Use	Perceived Usefulness	0.316	5.914	0.000	1.000

R^2=0.100 F=4.563 *P<0.001*

Table 6. Path analysis results of H7

Dependent Var.	Independent Var.	Standardized beta	t	P	VIF
Intention to use	perceived usefulness	0.577	4.529	0.000	1.000

R^2=0.333 F=20.511 *P<0.001*

Table 7. Path analysis results of H8

Dependent Var.	Independent Var.	Standardized beta	t	P	VIF
Intention to use	perceived ease of use	0.150	0.971	0.337	1.000

R^2=0.022 F=0.944 *P<0.001*

system could not be judged based on their perceived ease of use of the system.

DISCUSSION

In the integrated BIM & cost estimating blended learning model developed in this study, the traditional face-to-face learning in the classroom was integrated with the web-based BIM & cost estimating system and project-based learning. Then the TAM3 theory was used to compare the experts' and novices' acceptance of this blended learning model. Finally, the path analysis method was used to verify the eight hypotheses developed in this study based on the TAM3 method and then further explore the cause-effect connections among the TAM3 variables in these hypotheses.

According to the analysis results, the experts and novices in this study were significantly different in their "intention to use", "perceived ease of use" and "computer anxiety". Through further interviews, it was found that the experts were aware of the bene-fits of this system for their performance at work due to their working experiences and, therefore, they had higher intentions to continue using the system in the future. By contrast, the novices did not have sufficient working experiences and unable to appreciate the possible benefits of this system for their future performance at work. Therefore, they had lower intentions to continue using this system in the future.

In terms of "perceived ease of use", the experts had more prior knowledge in the professional field and more experiences in using architecture-related soft-ware/systems. Therefore, they grew familiar with the system developed in this study more quickly than the novices and, therefore, had higher perceived ease of use of the system than the novices. Finally, in terms of "computer anxiety", the finding in this study is contrary to those of existing research that indicate experts are capable of predicting the difficulty of solving a problem more accurately and monitoring their problem-solving strategies more carefully than novices (Lesgold, 1988). According to the questionnaire results provided by the experts, it was because the experts in this study were aware of the importance of the data and contents in the system and, therefore, they were concerned about the risks of data losses and over-dependence on computer software/systems at the cost of losing personal judgmental sensitivity in construction project cost estimating.

Generally, according the analysis results in this study, experts and novices are mostly different in their attitudes and cognitive operations when learning new things. With rich working experiences, experts can build knowledge structures based on an abundance of existing schemas and solve problems more efficiently. It is suggested that, in terms of curricular design, structural and non-structural course contents should be integrated to expose students to problems of different difficulty/complexity levels so that they can build their schema and improve their problem solving capabilities more quickly.

According to the path analysis results in this study, all the first seven hypotheses in this study were sup-ported and significantly correlated with the two variables of "perceived ease of use" and "perceived usefulness". This indicates that the blended learning model developed in this study was generally accepted by the students. By contrast, there was no significant connection between "perceived ease of use" and "intention to use". It was probably because even though all the participating novices and experts had certain experiences of computer usage, it was still the first time for them to use the web-based BIM & cost estimating system. Therefore, it still required a certain level of professional knowledge and learning of how to use the system, particularly for the students, to become familiar with the system. In other words, students require "learning by doing" before they can grow completely familiar with the system and use it for their own learning. This can not only improve the usability of the system for students but al-so enhance their understanding of the system so that they will have stronger intention to use it.

In addition, the following TAM3 dimensions of the integrated BIM and cost estimating blended learning model: "job relevance", "output quality", "result demonstrability", "computer self-efficacy", "perceived usefulness" and "intention to use", are all significantly correlated with each other. This finding supports Davis' proposition (Davis, 1986) that learning is helpful for users and must be implemented. Generally speaking, the subjects in this study believed the web-based BIM & cost estimating developed in this study could provide positive and highly efficient assistance for their professional performance in terms of construction project design and cost estimating. The negative correlation between "computer anxiety" and "perceived ease of use" is an expectable finding. When users do not feel anxiety in operating on or using a system, they will feel the system easy to use.

Also according to the analysis results, the users' "perceived usefulness" of the web-based BIM & cost-estimating system in this study had a significant influence on their "intention to use" the system. It was probably because, before the students had positive expectations of what they were going to learn in the courses. Therefore, they had positive expectation of the learning activities in this system, which helped to enhance their willingness to use the system. This finding is consistent with the conclusions of the TAM research by Davis (Davis, 1986) that (1) customers' perceived usefulness of an information technology will have a positive influence on their use attitudes toward the technology" and (2) customers' perceived ease of use of an information technology will have a positive influence on their use attitudes toward the technology.

CONCLUSION

In the classroom, students can only learn some basic knowledge about cost estimating within limited time without any thorough or repetitive practice for it takes a lot of time to calculate the costs. The blended learning environment developed in this study was generally accepted by all the participating students and it could also enhance the students' acceptance of the blending learning strategy that combines classroom-based education and online learning. Through the web-based BIM & cost-estimating system developed in this study, students can practice cost estimating anytime and anywhere so that they can properly build their own schemas about construction project cost estimating. Even though there are significant differences between novices and experts in certain variables as found in this study, students can still achieve desirable learning results through repeated and continuous practice and learn how to solve problems through "learning by doing" and discussions with their peers inside and outside the class-room. As a consequence, they will have better learning results in the end. Researchers or school teachers could apply the concept about the blended learning strategy to provide not only in-class teaching activities but also online learning activities to the students as well. Both the two teaching strategies were expected to help the student to obtain experiences and to develop the professional abilities of a real-world construction project in turns of the use of BIM system and cost estimation.

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APPENDIX

Appendix A: Reliability Analysis Results of the Dimensions and Standard Deviations of Each Dimension

Dimension		Question	SD	Cronbach's α
Intention to Use	1.	I plan to use this system to provide assistance for my learning or job in the future.	.784	0.724
	2.	I will recommend this system to others.	.750	
	3.	I would like to spend more time to understand how to use the system effectively.	.667	
	4.	I am willing to use the system in the future.	.626	
Perceived Usefulness	1.	Using this system can help me to complete my job.	.794	0.838
	2.	Using this system can help me to improve my work performance.	.694	
	3.	Using this system can help me to improve my work efficiency.	.773	
	4.	Using this system is helpful for my work.	.655	
	5.	Using this system can help to improve the quality of my work.	.813	
Perceived Ease of Use	1.	It is easy to use this system.	.771	0.714
	2.	It is easy to browse in this system.	.858	
	3.	It is easy to operate on this system.	.950	
	4.	The interfaces in this system are clear and easy-to-understand.	.741	
Job Relevance	1.	This system is relevant to my work.	.697	0.751
	2.	Using this system is suitable for the type of my work.	.958	
	3.	Using this system is suitable for the way of my work.	.793	
Output Quality	1.	I think the output contents of this system are of good quality.	.823	0.853
	2.	I think the output contents of this system are problem-free.	.756	
Result Demonstrability	1.	I can clearly tell others what I have learned after my use of this system.	.820	0.797
	2.	The results from using the system are clear and easy-to-understand.	.724	
Computer Self-efficacy	1.	I can still use this system even though I do not have any experience with it.	.969	0.702
	2.	I can still use this system without any teaching or instruction from others.	.902	
	3.	I can use the system only after someone demonstrates to me how to use it.	.983	
	4.	I can use this system for I have experiences of using similar systems.	.702	
	5.	I can correct errors in using the system.	.849	
	6.	I can use this system with confidence.	.763	
	7.	I am familiar with how to use the system.	.750	
Computer Anxiety	1.	I feel stressed when using this system. ◦	.763	0.709
	2.	Using this system makes me feel uncomfortable and restrained.	.663	
	3.	It is difficult to understand the computer technologies related to using the system.	.730	
	4.	I am worried that using this system will make me too dependent on the computer and lose my judgment capability.	.674	
	5.	Using this system makes me feel worried.	.741	
	6.	I am worried that an error in using the system will lead to data losses.	.798	
	7.	I am worried an error in using this system cannot be corrected.	.756	