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Design and Implementation of an iOS APP: Multimedia Interactive System and Items for Woodworking Teaching

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Abstract: This paper presents a computer-aided learning app based-on iOS platform, for the students trying to learn the woodworking skills. The app contains an interactive evaluation tool that can assess the learning effectiveness. Traditional woodworking usually involves many aspects of skills and knowledge, such as understanding the properties of materials, familiarization of operation of woodworking tools, innovative manufacturing, and production skills, etc. Basic university woodworking courses include theoretical courses and practical ones. After summarizing and analyzing these courses, we designed an interactive learning simulation system of basic woodworking, a system divided into three parts: concept learning, tool operation, and material processing. In this study, 12 freshmen and sophomores of university students participate in pre-test and post-test of the experiment of learning effectiveness and they also do a survey of System Usability Scale. The results show that the multimedia interactive system can effectively improve the effectiveness of learning woodworking concepts, and can stimulate students' interest in learning. This result is also reflected in the SUS scale.

Keywords: Interactive learning, computer-aided learning, interactive textbook, woodworking teaching, app

1. Introduction

Vocational Technical Education (VTE) is crucial for educating people to bring them a profession needed in all areas of life (Karahoca et al., 2010). The development of Industry 4.0 brings about many advanced technologies and knowledge, and it also expands new vocational skills, content and methods all the time (DURMUŞ & DAĞLI, 2017). Karahoca and Dulda's research on vocational and technical education students proves that the use of interactive electronic media to simulate educational content is beneficial and can be even regarded as a solution to the shortage of professional educators, space and materials in this field (Karahoca et al., 2010). The research of Balan and Kalavally indicates that the popularization of computer-assisted teaching software has led to major breakthroughs in learning strategies and implementation methods. The teaching software is often accompanied by a good interface, which can increase the interaction between students and teaching materials, and also improve students' learning effectiveness (Balan & Kalavally, 2012). Computer-assisted learning is a form of self-guided learning that can be presented through text, vision, voice, and motion digital files, thus providing a multimedia approach to learning (Aruna & Thenmozhi, 2014).

Compared with conventional courses which emphasize process control, interactive apps with well-designed tablet interfaces allow students to learn various subjects with more fun and better light and sound effects, making them more motivated, and enhance their satisfaction and performance indicators (Huang, Wu, Chen, Yang, & Huang, 2012). With maturity of tablet computer technology, wireless network can make up for the storage of space with the benefit of its high portability, so students can easily learn independently anywhere (Aruna & Thenmozhi, 2014). de Freitas has concluded in the literature review of game-based learning that games and simulations undoubtedly have great learning potential (De Freitas, 2006). The main purpose of game-based computer-assisted teaching is to provide learning contexts to help students learn or familiarize themselves with skills. It can also provide entertaining and challenging games to enhance students' motivation and enable students to achieve learning results in games (Huizenga, Admiraal, Akkerman, & Dam, 2009).

Hlophe found that various factors had a negative impact on the woodworking industry and carpentry teaching, such as lack of sufficient teaching resources, lack of qualified teachers, lack of basic tools and machinery, poor and limited funding, inadequate parent/guardian cooperation, limited industrial participation and governmental support (Hlophe, 2019). In addition, woodworking-related courses often require various large-scale operating tools and machines for implementation (Okwori, 2012). Real sites and equipment need to be built (Kaçar & Bayılmış, 2013).

Vocational and technical education courses often include theory and practice. For example, in traditional woodworking-related courses, theoretical teaching will be carried out first in the classroom, and then practical operation courses. If computer-assisted teaching methods can be applied to teach theory and practice in the course and simulate the experimental environment on a tablet computer, the cost of building a practical environment can be reduced. Students do not need to wait; they can also perform operations at the same time. By repeating operations to learn, they will get enough experience and understand how to transform theories into practice (Kaçar & Bayılmış, 2013). After students are readily prepared, hands-on courses can be carried out in proper time. This way, learning can be more efficient and effective. Success rate of experiments can be enhanced while the waste of necessary resources can be reduced.

In order to solve the aforementioned problems and achieve the following goals: 1. Computer-assisted game-based learning; 2. Directly interact with teaching materials to deepen learning; 3. Assess and analyze system usability. Therefore, this study develops a set of interactive learning system of basic woodworking that includes theoretical and practical courses. Tablet computers are used as a tool to implement computer-assisted learning, allowing students to perform repetitive exercises and simulate operations after finishing theoretical courses. Students can learn the correct operation steps and execution sequence through repeated exercises to increase learning effectiveness.

2. Related Work

Olabiyi and other researches believe that the use of Computer Assisted Instruction (CAI) technology in skill courses can make students better understand the classroom goals and course outlines (Olabiyi, Aiyelabowo, & Keshinso, 2013). Jose et al. have developed an economical and efficient system that can simulate various common tool exercises and procedures in a virtual environment. The virtual environment also provides visual, tactile and performance feedback, which can offer a realistic experience for vocational training courses. Compared with traditional training methods, this can better improve skill learning (Jose, Unnikrishnan, Marshall, & Bhavani, 2016).

Lee's research indicates that furniture carpenters need a lot of understanding and judgment of views and space, which is the primary technique for learning furniture manufacturing. The spatial geometry concept of timber joint structure is usually difficult to understand. Beginners often miscut useful parts, or eliminate ready fabricated parts due to misjudgments, resulting in assembly failure or shortage of materials (Lee, Hsu, Chen, & Zheng, 2019). Grytnes' and Regine's research on carpentry apprentices dealing with uncertain and hazardous work indicates that learning how to work and how to handle uncertainties related to health and safety issues at work is a comprehensive practice, and the prerequisite for learning is participation (Grytnes, 2018).

The introduction of game elements, methods and technologies into the general learning environment is a process of gamification of learning. Through interactive operation experience, it can be made more positive meaning, which can increase the user's interest, participation and learning effectiveness (Hlophe, 2019). The "game-based learning method" is more effective in acquiring knowledge than the "traditional teacher-based learning method", but there are still many aspects that require more in-depth research. For example, Papadakis et al. developed a set of ancient Greek drama teaching 3D serious interactive games called "ThimelEdu", with the purpose of testing whether this method helps students develop knowledge, and found that students' knowledge has increased and their performances are significantly different (Aladé, Lauricella, Beaudoin-Ryan, & Wartella, 2016; El

Mawas, Truchly, Podhradský, & Muntean, 2019; Papadakis, 2018; Papadakis & Kalogiannakis, 2019; Papadakis, Trampas, Barianos, Kalogiannakis, & Vidakis, 2020).

3. Methodology and Result

3.1 Map of Woodworking Learning Concept

With systematic integration and organization of basic woodworking courses offered by universities, three parts are proposed: tools, skills, and materials and a map of learning concept is drawn, see Fig1. Users can clearly understand the learning content, and self-examine and strengthen the parts unfamiliar to them. The content of the tools mainly focuses on commonly used wood processing tools such as hand saws, hand planes, chisels, etc., and the teaching of different categories and operations of tools will be conducted. The part of skills consists of "grinding and finishing technology" and "timber joint". Grinding includes the skills and steps of grinding with tools such as grinder sharpeners. Sanding refers to the fine-tuning techniques with the cutting tools such as planers. The teaching of wood joints involves different situations to use butt joints, groove joints, tongue and groove joints, etc. Also, the design of the timber joints and the combined interface between the wood will be learned. The part of materials includes teaching methods and procedures for drying wood artificially and naturally, processing natural wood into plywood for future use in furniture making, as well as the advantages and disadvantages of different plywood wood materials. Finally, conversions of international measurement units and the commonly used Taiwanese measurement units will be taught. This research aims to help students get a picture of learning woodworking with the map of learning concept and know what knowledge they are not familiar with, so that they can improve themselves and achieve good self-learning results.

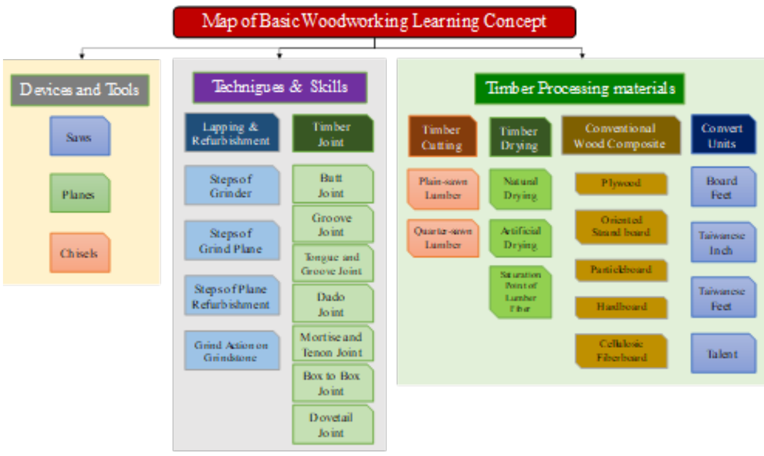


Figure 1. Map of basic woodworking learning concept

3.2 Interactive Model

This interactive model is designed based on more distinctive topics. There are three types of interactive models: “Timber Joint”, “Wood Cutting”, and “Plywood Combination”.

The “Interactive Model of Timber Joint” is divided into six procedures (see Fig 2). S0 means that you are ready to answer after entering the question. S1 means reading the question and thinking about how to answer it. S2 indicates that the user has started to drag and drop the object to answer. S3 is based on the drag and drop status of S2 to make real-time graphical presentations. After S3, the user can choose to return to S1 and read the question again to think about whether the answer is correct, or return to S2 and continue dragging other objects, or enter S4 to unlock the wrong part and the user can still return to S1 and S2 to rethink and answer, or end the remaining answers. Finally, the actions performed of S2, S3, S4, and S5 will be recorded in S6 as the data basis for subsequent behavior analysis. If the answer has been completed, the user can enter S5, and then he can leave this question and enter the next question.

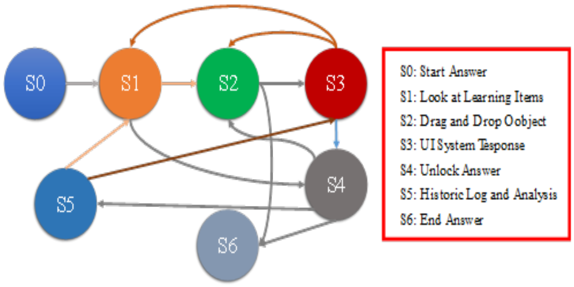


Figure 2. Interactive model of timber joint

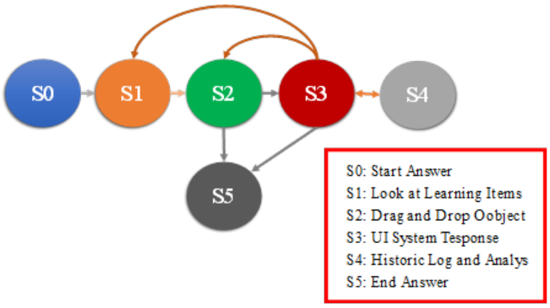


Figure 3. Interactive model of timber cutting

The "Interactive Model of Timber Cutting" (see Fig3) is divided into six procedures. First of all, S0 indicates entering the question. S1 means observing the question and thinking about how to answer. S2 means that the user starts to operate according to the options provided by the system. S3 presents a real-time graphical state according to the answer options selected by the user in S2. After reaching S3, the user can choose to return to S1 to rethink, or enter S2 to continue the operation, or to make the correct answer, and then directly enter S5 to end the answer and leave the question. During the answering process, the operation records and data of S2 and the graphical status of S3 will be recorded in S5 for subsequent behavior analysis.

The "Interactive Model of Plywood Combination" (Fig4) is divided into nine procedures. First of all, S0 represents entering the question. S1 is observing the question and thinking about how to answer. S2 means that the user starts to drag and drop the object to answer. S3 determines the relationship between the upper and lower levels of the objects according to the user's operation in S2. S4 and S5 can choose whether to perform Group or UnGroup actions with other options according to the operation of S2. According to the four operations of S2, S3, S4, S5, S6 presents an instant graphical state. The operation history of the entire answering process will be uniformly logged by S7 and used for subsequent behavior analysis. Finally, if the answer is completed, the user can end the answer with S8 and quit the question.

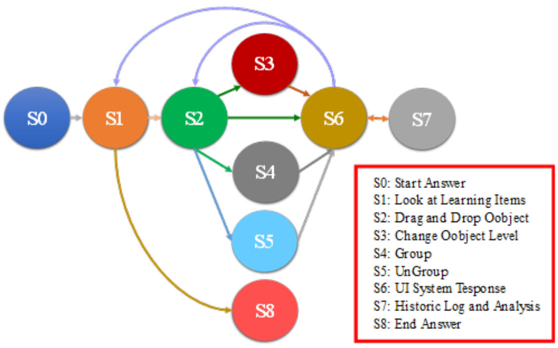


Figure 4. Interactive model of plywood combination

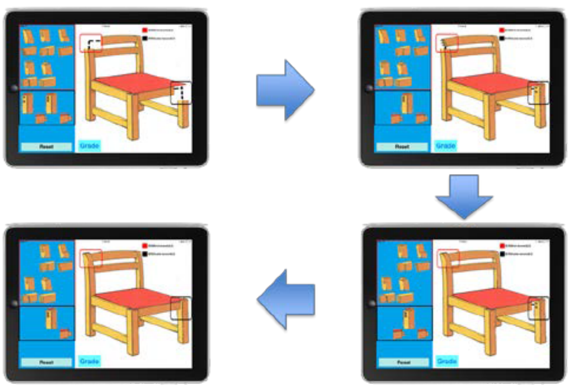


Figure 5. Screenshot of Timber Joint items' operating process

3.3 Teaching Items

According to the "Map of Basic Woodworking Learning Concept", six characteristic teaching topics are designed: "Timber Joint", "Timber Cutting", "Timber Drying", "Timber Fiber Saturation Point", "Plywood Combination", and "Timber Size". The following are two examples:

In the items of "Timber Joint" (Fig. 5), the operator needs to make chair structure combination with the specified joint method. That is, according to the color of the answer area, the user pulls in the appropriate answer from the left menu column, and presents the type of timber joint required by the question in the answer area.

Timber drying is designed based on the "Timber Drying Concept" in the "Map of Basic Woodworking Learning Concept", with the purpose of testing whether the user is familiar with using the kiln and performing manual drying steps (see Fig. 6). The user answers the question by operating three groups of "Wet controller" and "Temperature controller". The “UI System Response” will provide real-time graphical display based on the user's adjustment of the controller.

Figure 6. Screenshot of Timber Dry items' operating process

4. Methodology and Result

There are 12 freshmen and sophomores of university students participate in pre-test and post-test of the experiment of learning effectiveness and they also do a survey of System Usability Scale , including 1 female and 11 males.

4.1 Experiment and Results

The participants use the interactive learning system of basic woodworking to conduct self-learning, and then take the post-test. Most of the scores in the paper-pencil test have grown. Judging from the paired-sample T test in Table.1, it can show P (.029<.05), and the data analysis shows a significant difference. It means that the use of interactive learning system of basic woodworking is helpful for learning carpentry knowledge.

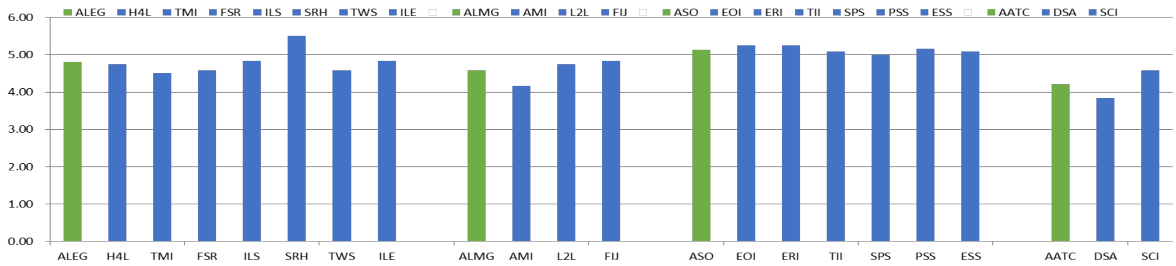
Table 1. *Paired-Sample T Test Table*

	Paired Differences							
				95% Confidence Interval of the Difference				
	Mean	Std. Deviation	Std. Error Mean	Lower	Upper	t	df	Sig. (2-tailed)
Pair 1 Pretest - Posttest	15.833	21.933	6.332	1.898	29.769	2.501	11	0.029

*p:<0.1, **p:<0.05, ***p<0.01

4.2 The Statistics of System Usability Scale

The System Usability Scale is divided into four parts: "growth of learning motivation", "growth of learning effectiveness", "system operation usability", and "appropriateness of learning content " for the scale statistics (Fig. 7). Its reliability to be at or just over 0.90 (Bangor et al., 2008; Lewis et al., 2015a,b; Lewis and Sauro, 2009). It can be seen from the average that participants generally have a higher evaluation of the controllability of the system. They think that the operation of the basic interactive woodworking learning system is intuitive and simple. The participants have higher acceptance of learning through the interactive learning system of basic woodworking than paper-pen tests, which means that students generally prefer to use tablet computers to learn the course content.



- ALEG: Average of learning effectiveness growth
- EOI: This system is easy to operate in interface design
- ERI: This system is easy to read in the presentation of information.
- DSA: The difficulty of this system is appropriate.
- SCI: This system has continuity and integration.
- AMI: This system can arouse my learning motivation and interest.
- H4L: Using this system is helpful for learning.
- L2L: Like to use this method to learn.
- ALMG: Average of learning motivation Growth
- TMI: Study the teaching materials and improve my skills with practical operations.
- PSS: Overall, I am satisfied with the practicality of the system.
- ASO: Average of system operability
- FSR: After using this system, I feel rewarded.
- FIJ: Using this system feels to increase the joy of learning.
- ILS: Using this system can improve my learning skills.
- SRH: Compared with the written test, the acceptance of using this system is relatively high.
- TWS: This system can test the proficiency of woodworking skills.
- ILE: Using this system can improve my learning efficiency.
- AATC: Average of appropriate textbook content
- TII: Feel that there is interaction with the system.
- SPS: In general, the service provided by this system is satisfactory.

Figure 7. Chart of System Usability Scale

5. Conclusion and Future Works

Woodworking courses need to accumulate operating experiences by operating large-scale machinery, but students often need to take turns doing that in the real classroom, and therefore waste a lot of time waiting. At present, common teaching APPs are mostly presented in the form of e-books. For practical skill courses, they lack interactive elements. Based on the basic woodworking courses offered by the universities, this study has proposed a " Map of Basic Woodworking Learning Concept " and an interactive learning material for self-learning of basic woodworking courses with iPad tablet computers. The content of this interactive learning material simulates the practical operation skills of woodworking machines and the concepts of woodworking material processing procedures, etc., allowing users to improve their practical ability and basic concepts of woodworking through the practice in an interactive learning system.

This study also carries out a study effectiveness experiment and a questionnaire survey on the “System Usability Scale”. The results of the study effectiveness experiment show that the developed interactive teaching materials have significant results. The statistical results of the system usability scale show that users generally give high evaluations to the use of interactive learning materials, and believe that learning through tablet computers is more popular than pen-paper.

In the future, more basic woodworking courses and development item editors will be added, so that teachers can develop course materials without a programming background, and use this experience to develop interactive learning systems for other subjects.

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