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Abstract

Augmented reality (AR) integrates virtual information into a learner's physical environment, so that the learner will perceive that information as existing in the environment. Many augmented reality applications were quite successful in previous educational environments. This study attempts to build a prototype of augmented reality learning system for health care and to enable learners to make use of extensive interactions with the system and real world. After that, this study is evaluated by the learners' motivation and intention to use the AR learning system. The results showed that immersion and interactivity features were two predictors for learners' motivation. Furthermore, learners' motivation is the most important factor to affect learner's behavioral intention to use an AR learning system.

Keywords: interaction, presence, immersion, motivation, augmented reality

1. Introduction

The technical enablers for augmented reality (AR) are becoming popular enough to allow the educators to develop of AR applications for learners. Augmented reality systems integrate virtual information into a user's physical environment so that the user will perceive that information as existing in the environment. In other words, augmented reality refers to most of images that are real and can interact with the virtual world in real-time. The advanced technology is more likely to a powerful and intuitive interaction, efficient visual communication, integration of rich media and delivering high quality learning contents generated and managed by educators [1].

Interaction, immersion, and presence are three important features of virtual reality [2]. Interaction is for learners able to detect a user's input (ie, gesture) and respond to the new activity instantaneously. Thus, the use of 3D computer

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generated graphics in combination with various interface devices provides the effect of immersion in an interactive virtual environment. Learners can interpret visual, auditory, and haptic cues to gather input information to navigate and control objects in the synthetic environment to accomplish physical immersion. In physical immersion, learners are immersed in a scene which changes in response to their inputs and actions. Presence emphasizes learners' feelings of visiting a place rather than viewing 3D images generated by computers. In short, presence is a learner's personal subjective feeling of behaving in a virtual environment as in the real world.

The paper is organized as follows. In the next section, we build an augmented reality learning system that we research in this paper, and research hypotheses are given. In Section 3, the experimental procedure and results are presented. Finally, discussion and conclusion are given.

2 A case study of augmented reality learning system

2.1 System development

The augmented reality learning system allows learners to explore body organs related knowledge in immersive learning environment. The system is designed to offer basic concepts of anatomy and health care by integrating D'Fusion into Virtools 4.0. The 3D system components using 3d object sourced from Turbo Squid. The system's 3D graphic modules were drawn and rendered using 3DsMax and Maya, then edited with 3Ds Max, and transformed into OBJ files for export to D'Fusion. Authoring tools included a 3D model export tool and a 3D model viewing tool from D'Fusion written in Lua Script.

This AR system provides learners with interactive control over virtual human internal organs through the use of physical cards and a webcam. The system and course contents were built by using Dreamweaver, the D'fusion web player, and Virtools, thus ensuring that the user has continuous access to the program without any additional program installation. Figure 1 shows how the learner uses a body organ card to control the learning process. The learner can rotate, observe, and zoom in/out on the 3D organs as shown in Fig.2, while Fig. 3 shows the learner accessing the course contents.

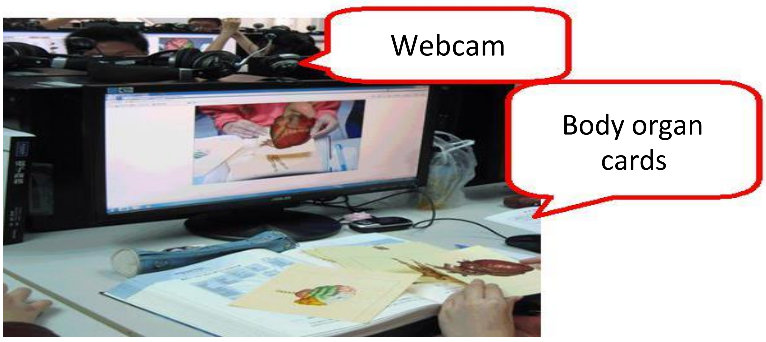

Fig 1. Learners participate in the experiment.

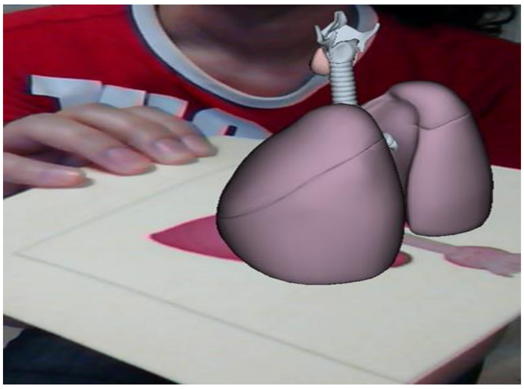

Fig.2. Learner rotates and observes an body organ.

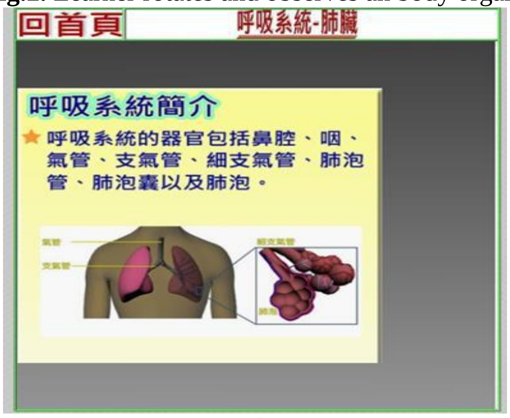

Fig. 3. Screenshot for course contents

2.2 Research hypotheses

AR allows learners to interact with 2D or 3D virtual objects integrated within a real world environment [3]. Learners can explore or navigate an AR learning environment and manipulate the 3D learning objects using a mouse or a body organ card. From the learners' perspective, there are three levels to AR technology in a virtual 3D learning system [4]. First of all, learners may engage in passive learning behaviour without actively influencing the learning environment. Learners can cause their virtual 3D character to move around the environment, examine 3D objects, or to learn presented contents (e.g., textual or audiovisual elements). Second, learners can actively engage with the learning environment, observing or interacting with any of the 3D learning contents. Third, learners may interact with other learners and objects that exist either in the virtual world or in the real world.

An AR system offers real-time feedback, using input devices to foster a sense of immediacy. The presence feature of AR learning provides learners with a sense of sharing space with others (e.g., Second Life). Immersion could allow learning to be situated in a comprehensive, realistic experience [5]. In education, AR has the potential to increase learner engagement and motivation to explore interactions between the real world instructional content and virtual objects in the AR learning environment. The three critical factors for motivating learning within VR applications are intuitive interaction, a sense of physical presence, and a feeling of immersion [6].

To investigating learner motivation to use AR learning systems, the study employed Keller's ARCS model to analyze learners' behaviour. The ARCS model is designed to assess how motivational aspects of learning environments (i.e., Attention, Relevance, Confidence and Satisfaction) stimulate and sustain learner motivation to learn [7]. Keller suggested that attention can be secured in two ways: (1) perceptual arousal uses surprise or uncertainly to increase interest through the presentation of novel, surprising, incongruous, and uncertain events; (2) inquiry arousal captures interest and stimulates engagement in questioning or problem solving. Relevance establishes that a learning process is relevant to the learner's needs and goals and will thus increase learner motivation. This concept emphasizes that learning should be tied to learners' personal experiences and be important to their further learning. Confidence holds that learners should achieve competence and success as a result of their abilities. To prepare for achieving their learning objectives, learners should prepare appropriate performance requirements and evaluative criteria. Satisfaction refers to the encouragement and support of learners' intrinsic enjoyment of the learning experience, as well as extrinsic rewards for their successes.

A 3D virtual learning environment may be used as a tool to enhance, motivate and stimulate learner acquisition of specific knowledge [8]. For example, Web-based anatomy instruction is generally perceived by medical students to be enjoyable and interesting [9]. Due to their direct engagement in the learning process through AR technology, learner motivation and interest is increased, leading to significant improvement in learning outcomes [10]. The authenticity derived from an AR learning environment enhances learner understanding of learning content and thus increases leaner motivation and interest in learning [5]. As a result, using AR technology makes learning more fun and effective for students [11].

Based on the concepts of immersion, interaction, and presence, we propose the following hypotheses:

H1. Increased immersion, interaction, and presence provided by an AR learning system increases learners' motivation to learn.

H2. There is a positive correlation between learners' motivation and intention to use an AR learning system.

3 Eexperimental procedure and results

3.1 Participants and measurement

Participants included 55 university students in central Taiwan, including 25 males and 30 females. The data for this study were gathered by means of a paper-and-pencil survey. The questionnaire was developed based on relevant literature [12,7] which served as the basis of the study's theoretical model. Each item was assessed based on the following criteria: (1) relevance to the objectives of this study, (2) appropriateness of wording and (3) clarity of the question. Items with assessed scores below a certain level were deleted. Unclear questions were modified or rephrased. To increase the validity of the measures used, 20 students participated in a pre-test. Based on the pre-test results, one question was discarded, leaving 19 questions formatted using a 5-point Likert scale ranging from 1 (strongly disagree') to 5 (strongly agree'). All subjects were asked to respond to the questionnaire and their responses were guaranteed to be confidential. Internal consistency and reliability were assessed using computing Cronbach's α, with alpha reliability found to be highly acceptable (α=0.91). The coefficients of the questionnaire items are presented in Table 1

Table 1–Means, standard deviations of each question (case study 2)

Items	M	S.D.
Interaction		
1. I can easily rotate 3D objects in the system.	4.47	.77
2. I can easily zoom in or zoom out on 3D objects in the system.	4.04	.77
3. I can easily observe 3D objects from various angels the system.	4.38	.71
4. I can interact intuitively with 3D objects in the system.	3.93	.96
5. I can conveniently interact with 3D objects in the system.	4.04	.88
Presence		
6. I feel that I have better understanding of spatial relationship of body organs by using this system.	4.29	.57
7. I feel that I have developed a better understanding of the relative positions of organs by using this system.	4.18	.67
8. Using this system has helped me develop a better understanding of the shapes of the various organs.	4.09	.80
9. I feel that I have developed a better understanding of the shapes of the various organs by using the system's representation mode.	4.15	.65
Immersion		
10. I feel the 3D simulated environment provided by this system is realistic.	4.00	.87
11. I feel the 3D simulated environment provided by this system is immersive.	3.73	.76

12. I feel that the 3D simulated environment helps me concentrate more while learning.	3.78	.88
Learning motivation		
13. I find the use of this representation style to be interesting.	3.98	.87
14. I enjoyed by using this representation style in the system.	4.16	.76
15. Using this representation style for the system was a novel experience for me.	4.11	.88
Intention to use the system		
16. I think this system can strengthen my intention to learn.	3.76	.98
17. I feel the system can enhance my willingness to learn.	3.65	.80
18. I am willing to continue using this system in the future.	3.78	.88
19. The system is helpful for my learning.	4.02	.81

3.2 Results

According to the results, 49.1% participants have over 10 years for computer experience. 19 of 55 participants had used augmented reality environment (34.5%) and 9 of the participants had used augmented reality environment for learning (16.4%). Moreover, 36.4% learners had used augmented reality game. Only 6% learners had experience in learning the health care related course.

For investigating hypotheses H1and H2 the predictive model is an acceptable statistical method because the Pearson correlations among two variables are all below .61. The results of stepwise multiple regressions for the path associated with the variables are presented in Table 2 To investigate H1 a regression analysis was performed to check the effects of immersion, interaction, and presence on learning motivation of a learner's intention to use an AR learning system. The result showed that immersion and interactivity factors were two predictors and immersion is the most important predictor ($F(2, 52)=15.72$, $p<0.001$, $R2=0.38$). To examine H2 a regression analysis was performed to check the effects of learning motivation on a learner's intention to use an AR learning system. The result showed that learning motivation was an important predictor ($F(1, 53)=31.37$, $p<0.001$, $R2=0.37$).

Table 2– Regression analysis result

H*	Dependent variables	Independent Variable	β	R^2	P
H1	Learning motivation	Immersion	.47	.32	<0.001
		Interaction	.26	.06	=0.03
H2	Intention to use the system	Learning motivation	.61	.37	<0.001

H*: hypothesis.

4 Discussion and Conclusion

The highest mean score of interaction factor, “I can easily rotate 3D objects in the system”, is 4.47. The highest mean score of presence factor,” I feel that I have better understanding of spatial relationship of body organs by using this system”, is 4.29. The highest mean score of immersion,” I feel the 3D simulated environment provided by this system is realistic, is 4.00. On the other hand, the highest mean score of learning motivation,” I enjoyed by using this representation style in the system”, is 4.16. The highest mean scores of intention to use the system,”The system is helpful for my learning”, is 4.02. Thus, learners perceive that the system is useful, so they want to use the learning system. The results of the study supported that perceived usefulness is the most significant contributor to positive learner attitudes toward the use of 3D virtual reality systems [12, 13].

The result showed that immersion and interactivity factors were two predictors for learners’ motivation. Furthermore, immersion is the most important contributor. This study supported that learners can explore or navigate in an AR learning environment, and interact with 3D learning objects [6]. Augmented reality has the ability to engage the learners and motivate them to explore in immersion contexts between the instructional materials from real world with virtual objects created by AR technology [6].

The results showed that learning motivation was a predictor for a learner’s intention to use an AR learning system. AR technology can offer the opportunity to create user friendly and immersion learning environment that could be useful environment for learning. Thus, educators would like to take advantages on the learning motivation to use AR technology, which affects learners’ intention to engage in learning activities.

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