行政院國家科學委員會補助專題研究計畫 □成果報告 ■期中進度報告

數位學習融入性,使用意向,使用效能之探討:從理論到應用

（第 2 年）

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1. Introduction

The use of animation and 2D multimedia for learning is now further extended by the provision of entire 3D Virtual Reality learning environments (VRLE) This highlights a shift in Web-based learning from a conventional multimedia to a more immersive and interactive, intuitive and exciting VR learning environment (Chittaro & Ranon, 2007; John, 2007; Monahan, McArdle & Bertolotto, 2008; Rauch, 2007). VRLEs simulate the real world through the application of 3D models that initiates interaction, immersion and trigger the imagination of the learner. These characteristics make VRLE a superior learning environment over a two dimensional multimedia learning environment. Since emerging technology such as VRLE become popular in education, the question of use of technology innovations comes into focus once again. This research is based on two different cases to discuss how learning effects of VRLEs.

2 Case study 1: Web-based 3D VR interactive learning system

2.1. Web-based 3D VR interactive learning system

WVBS-ATS, Web-based Virtual Body Structures Auxiliary Teaching System, is a Web-based 3D VR interactive learning system that is designed for undergraduate medical students to obtain knowledge about the structure of human body. The Web-based VR learning system is designed in three parts: Web pages, Web server and Database. The developer used PHP, Java Script to design the web page and utilizes Autodesk 3dsMax and VR4MAX to build the 3D body organ modules. 3dsMax is a commercial software package used to create 3D models. With 3dsMax, users can quickly and easily visualize the 3D objects without knowing any special computer language or having to export application-specific files. VR4MAX provides high performance real-time interactive virtual reality environment. For the Web server part, the website administrator used Apache and PHP to establish a web server and the MySQL database to access text data. In addition, we built an FTP Server to store the 3D module files. Students feel free to study any medical subjects by using the mobile VR learning system as they wanted. Moreover, learners can discuss with others by using discussion boards in the VR learning system. Figure 1 shows the structure of VBS-ATS.

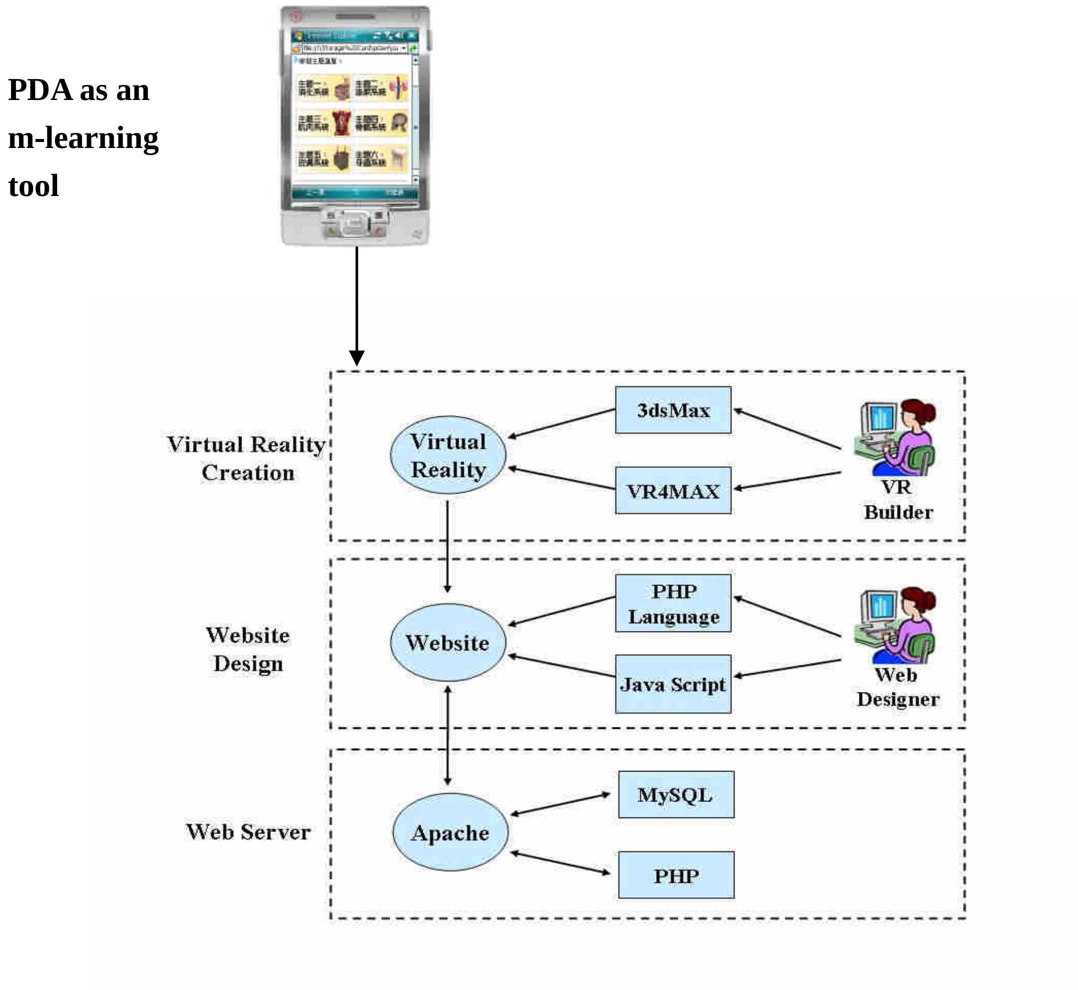

Figure 1: Structure of VBS-ATS

2.2. Research hypotheses

The three critical factors of VR applications for motivating students' learning are the intuitive interaction, the sense of physical imagination, and the feeling of immersion. VR applications should aim to simulate reality as faithfully as possible. Sutcliffe (2003) stated that successful VR application should have the following characteristics: (a), natural engagement. Interaction should approach the user's expectation of interaction in the real world as far as possible. (b), natural expression of action. The representation of the imagination in the VR should allow users to act and explore in a natural manner and not restrict normal physical actions. (c), realistic feedback. The effect of the user's actions on virtual world should be immediately visible and conform to the laws of physics and the user's perceptual expectations. It means that realistic feedback provides effective interaction. (d), navigation and orientation support. The users should always be able to find where they are in the VR environment and return to known, preset positions. In other words, navigation and orientation support high immersion. And (e), sense of imagination. The user's perception of engagement and being in a 'real' world should be as natural as possible.

Therefore, based on immersion, interaction, and imagination, we propose the following hypotheses:

H1: With the increase immersion, interaction, and imagination of a VR environment provides, the motivation of the environment increases.

H2: With the increase immersion, interaction, and imagination of a VR environment provides, the problem-solving capability of the environment increases.

2.3. Participants and measurement

This study conducts a survey for understanding learner attitudes toward the VR leaning environments. A total of 190 university students were taught on how to use the system. Students were allowed to use the system anytime for a period of one month. After that, a questionnaire survey was distributed to participants during class to understand VR leaning environments. Participants were invited to complete the questionnaire. All subjects were asked to respond to the questionnaire and their responses were guaranteed to be confidential. All 190 students filled the questionnaire survey. However, 23 missing responses were eliminated. Therefore, the study group comprised of 167 students which includes 68 male students and 99 female students.

The data for this study were gathered by means of a paper-and-pencil survey. Regarding to Attitudes towards VR, Participants were asked to indicate their attitudes. These 16 questions were adopting a 7-point Likert scale (ranging from 1 which means ‘‘strongly disagree’’ to 7 which means ‘‘strongly agree’’).

2.4. Results

The internal consistency reliability was assessed by computing Cronbach's αs. The alpha reliability was highly accepted (α=0.94) and coefficients of questionnaire items are presented in Table 1. Given the exploratory nature of the study, reliability of the scales was deemed adequate.

Table 1: The Mean, Standard Deviation, item-total correlations of VR from 1 which means "strongly disagree" to 7 which means "strongly agree")

Items	M	S.D.
Perceived immersion of using VR:		
The 3D simulation system creates a realistic-looking learning environment.	5.26	1.26
I pay more attention when using the 3D simulation system.	5.51	1.11
I feel immersed in the 3D simulation system.	5.29	1.23
Perceived interaction of using VR:		
I would like to share my VR learning experience with other learners.	4.79	1.30
The system can enhance teacher-learner interaction.	5.43	1.12
The system can enhance learner-learner interaction.	5.45	0.93
Perceived imagination of using VR:		
The system gives me more engagement to help me understand learning content.	6.15	0.83
I feel the system improves my understanding by the imagination of the body structure.	6.11	0.87
I feel the system helps me better understand by the imagination the relative positions among organs.	5.92	1.15
Perceived motivation of using VR:		
It is impressed using the VR system for learning.	5.74	1.05
The system can enhance my learning interest.	5.58	1.19
The system can enhance my learning motivation.	5.67	1.07
Enhanced problem-solving capability after using VR:		
The system can enhance my learning capability.	5.40	1.20
The system can enhance my problem-solving capability.	5.50	1.12

The system can enhance my capability of knowledge construction.	5.38	1.14
The system can enhance my capability of knowledge management.	5.24	1.21

For investigating hypotheses H1 and H2, the predictive model is an available statistical method. 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 perceived immersion of using VR, perceived interaction of using VR, and perceived imagination of using VR on perceived motivation of using VR. The result showed that three factors were all predictors and perceived immersion of using VR had more contribution than other two ($F(3, 164)=69.72$, $p<0.001$, $R^2=0.55$). To examine H2, a regression analysis was performed to check the effects of perceived immersion of using VR, perceived interaction of using VR, and perceived imagination of using VR on enhanced problem-solving capability after using VR. The result showed that three factors were all predictors and perceived interaction of using VR had more prediction than other two ($F(3, 164)=142.87$, $p<0.001$, $R^2=0.72$).

Table 2: Regression results of VR

H*	Dependent variable	Independent variables	β	R^2	P
H1	Perceived motivation	Perceived immersion	0.32	0.46	<0.001
		Perceived interaction	0.31	0.07	<0.001
		Perceived imagination	0.24	0.02	=0.001
H2	Enhanced problem-Solving capability	Perceived interaction	0.49	0.60	<0.001
		Perceived immersion	0.26	0.10	<0.001
		Perceived imagination	0.24	0.02	<0.001

H*: hypothesis.

3. Case study 2: Collaborative virtual reality learning environment

3.1. Collaborative virtual reality environment for medical education

The learning system, a Java-based program, is named 3D Human Organ Learning System – 3D-HOLS. With Java's cross-platform capability, 3D-HOLS runs in various system platforms. 3D-HOLS was being developed under both Windows and Linux environments. 3D-HOLS has been tested to be compatible with Windows XP, Vista, Mac OS X, and Red Hat Linux. 3D-HOLS provides two operating modes. The first mode is single user self-learning mode. In this mode, individual learners interact with 3D organs and read course web pages. The second mode is collaborative learning mode. This mode allows multiple learners to interact, practice and discuss in a virtual space. Figure 2 through Figure 4 depicts a typical classroom scenario. To begin collaborative learning, the instructor may initiate a 3D-HOLS server instance. Learners input instructor's IP address to connect to the server. The server instance has power to assign control privilege to a learner. These operations are shown in Figure 2, 3, and 4.

Figure 2: Collaborative set up in a typical classroom setting. The instructor initiates a 3D-HOL server instance.

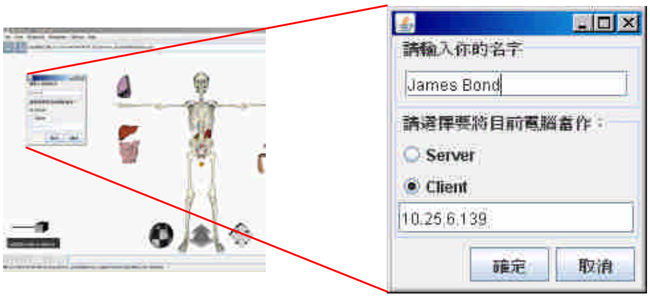

Figure 3: Students enter their names and server's IP address.

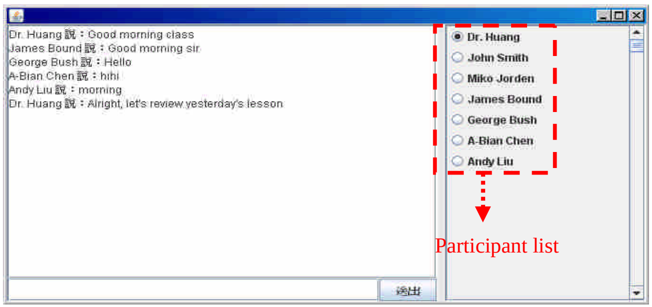

Figure 4: The server instance maintains a list of participants. Server assigns control privilege by clicking radio button next to user name.

3.2. Research hypotheses

In order to examine users' attitudes and intentions of using 3D-HOLS system, the three features (immersion, interaction and imagination) of VR should be considered. The research model served as a guideline for formulating questionnaire and systematically performing statistical analyses to test the hypotheses. First, the three features were investigated to see whether they have positive influence on the collaborative learning. Thus, the hypothesis was proposed as follows:

H3: When using the 3D-HOLS system, the three features of interaction, immersion, and imagination will have positive impacts on collaborative learning.

Having investigated the relationships between the three features of interaction, immersion, and imagination and collaborative learning, the predictive relationship between collaborative learning and behavioral intention of using 3D-HOLS system was then examined. Therefore, a hypothesis was proposed:

H4. There is a positive correlation between collaborative learning and students' behavioral intention to the 3D-HOLS system.

3.3. Participants and measurement

Participants included students from school of Medicine, school of Pharmacy, college of Chinese Medicine and college of Health Care. All participants have taken at least one medical informatics course. A total of 76 valid responses were collected that including 48 are males and 28 are females. The data for this study were gathered by means of a paper-and-pencil survey. The questionnaire included two major components: (a) demographic information, (b) attitudes toward collaborative learning. These 25 questions all adopted 7-point Likert scales (from 1 which means "strongly disagree" to 7 which means "strongly agree").

3.4. Results

The internal consistency reliability was assessed by computing Cronbach's α s. The alpha reliability was highly accepted (α=0.92) and coefficients of questionnaire items are presented in Table 3.

Table 3 –The means, standard deviations of each question.

Items	M	S.D.
Interaction		
By using this system, I can easily translate and move 3D objects.	5.97	0.94
By using this system, I can easily rotate 3D objects.	6.00	0.92
By using this system, I can easily zoom in or zoom out 3D objects.	6.08	0.90
By using this system, I can easily observe 3D objects from various perspectives.	5.96	1.03
It is easy to interact with other team members by using this system.	5.47	1.04
Imagination		
I feel that it is easier to understand anatomical structures by using this system.	6.11	0.81
I feel that I have developed better understanding of structures and orientations of organs by using this system.	6.12	0.78
I feel that I have developed better understanding of relative positions of organs by using this system.	5.99	0.77
Using this system has helped me develop better understanding of shapes of every organ.	5.82	0.88
It is easy to use the collaborative learning functionality to help memorize the relative positions of organs.	5.67	0.86
It is useful to use the collaborative learning functionality to help memorize the relative positions of organs.	5.71	0.83
Immersion		
I feel the 3D simulated environment provided by this system is realistic.	5.34	1.07
I feel the 3D simulated environment provided by this system is immersive.	5.18	1.14
I feel that the 3D simulated environment makes me concentrate more while learning.	5.24	1.03
Collaborative learning		
I can immediately ask questions when problems arise.	5.46	0.94
I can immediately obtain help or solutions when necessary.	5.36	0.98
The collaborative learning system allows me to discuss with team members.	5.63	0.89
I am able to complete organ assembly exercises with team members.	5.61	0.94
It is useful to use the collaborative learning environment to study human anatomy.	5.57	0.85
I am indeed working with team members and solving problems together.	5.45	0.92
This system allows me to interact with classmates more frequently.	5.43	1.01
Intentions to use the system		
I think this system can strengthen my intentions to learn.	5.26	0.87
I am willing to continue using this system in the future.	5.29	0.92

I wish that other classes also adopt 3D collaborative virtual system to facilitate my learning.	5.51	0.93
Overall, I think this system is worth to be a good learning tool.	5.76	0.83

Multiple regression analysis has been widely adopted for empirically examining sets of linear causal relationships. For testing H3, a regression analysis was conducted to check the effect of interaction, immersion, and imagination on collaborative learning. The results explained that imagination, interaction and immersion variables were all predictors for the collaborative learning ($F(3,72)=21.32$, $\underline{p}=0.000$, $R^2=.47$). The imagination was the biggest contributor (37%). On the other hand, the result of testing H4 was collaborative learning can predict intention to use the VR learning system ($F(1,74)=105.71$, $\underline{p}=0.000$, $R^2=.59$) as shown in Table 4. The factor of collaborative learning by itself provides 59% of contributions for students' intention to use the 3D-HOLS. In addition, all p-values are below 0.1% significance levels.

Table 4 – Regression analysis result

Dependent variables	Independent Variable	β	R^2	P
Collaborative learning	Imagination	0.38	0.37	<0.001
	Immersion	0.25	0.07	<0.001
	Interaction	0.18	0.03	<0.001
Intention to use	Collaborative learning	0.77	0.59	<0.001

4. Discussion and conclusion

Based on these two cases, we provide evidence that VRLEs have positive effects on learning purpose if we apply those learning environments appropriately. These two case studies propose VRLEs could assist collaborative learning and problem-based learning; furthermore, those learning environments also could enhancing learners' motivation.

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國科會補助專題研究計畫成果報告自評表

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第二年的重點在於數位學習之多媒體數位化教材之融入性與使用意向探討. 而第二年的工作重點在於將先前已設計好之虛擬實境多媒體數位化教材讓學生使用之後, 在使用問卷調查之方式, 探討融入性, 互動性與想像力對於使用意向的影響. 目前已發表2篇SSCI期刊論文與4篇國際研討會論文.

Huang, H. M., Rauch, U, & **Liaw, S. S.** (in press). Investigating Learners' Attitudes toward Virtual Reality Learning Environments: Based on Constructivist Approach. Computers & Education.

(SSCI, SCI) (Corresponding author)

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