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The Effectiveness of Visualization System for Virtual Reality Learning

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Abstract

In this study, we developed a visualization tool that shows learners' interactive activities graphically during virtual reality (VR) education. Current VR system only shows learning content. However, we need to recognize learners' interaction and information exchanges for increasing effectiveness of learning; also we need to show it effectively. Therefore, we developed visualization tool for VR learning based on web 2.0, and this tool helps teachers and students to monitor and percept the interaction activities among students, and thus it facilitates their interaction and learning in VR education environment. For experiments, 68 students participated in VR learning. The result shows that the interaction and the perception of effectiveness of learning are significant differences between VR system and web 2.0 VR system. Furthermore, for verify availability of usage, TAM (Technology acceptance model) analysis about the system is supported. This result will be basic material for constructing of future VR learning environment.

Keywords*: Virtual Reality Learning, Web 2.0 tool, Visualization*

1. Introduction

Technology leads to change educational environment. Various learning contents are developed on the Internet, virtual reality content or three-dimensional contents spread out educational fields. VR learning facilitates to students feel seeing real objects with HMD (Head Mounted Display) [1,2], computer, or smartphone. This VR contents are made by VR language or PVR (Photographic Virtual Reality) method [2-4]. Especially, there are some cases of PVR learning contents about museums or heritages [5]. This VR learning helps students to study when they cannot go to museum and after going there [6]. However, it does not show participation of students and the information that produced by students. Previous learning tools consist of web board, collaborative working space and white board, but they do not support visualization tool [7,8].

Thus, we need a visualization tools for sharing and observing their activities and learning information. Kagan[9] said that collaborative learning has collaboration after recognition and coexistence: the steps of collaboration are introduction, learning and sharing. That is, the visualization tool that shows learning activity of students increase an effectiveness of learning. Recently, web 2.0 that support sharing, user creation, open source like as wiki or blog, RSS affects on educational fields [10]. Learners are able to use web 2.0 technology which is used their learning for making and sharing their information [11]. Dispatch

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Several studies have been made on education cases by web 2.0, but there have been a little study that tried to apply it to VR education. Also, these studies show that VR systems only support and deliver the learning contents to learner. It is necessary to facilitate learners' activity by supporting web 2.0 system on VR education: we developed and investigated the effect of this system on VR education and verified it with TAM (Technology Acceptance Model) method.

2. Related Works

2.1. Virtual Reality and Panorama Virtual Reality

Virtual reality started from the concept of videoplace by Myron Krueger in 1970 decade [12]. Virtual reality makes an imaginary world into the real world; it makes human feel as real world situation. These VR methods on web are divided by photographic based VR and object based VR; the former use VR background with photos and the latter use VR object with it [13]. In this study, we research panorama VR based on photographic VR. In Korea, there is the PVR system of cultural heritage at Kyonggi province in 2000 [14].

Also, Hong [5] analyzed 28 virtual museum sites and showed considerations for virtual learning. Some sites have three-dimensional animation and object virtual reality of a cultural relic. The problems of these museums are difficult to use it because of using of plug-in or usage of VR system.

2.2. Web 2.0 and Education

Web 2.0 is derived from the concept by Dougherty in Medialive international conference or O'Reilly in 2004 [15]. Web 2.0 is change that evolves into complete platform supporting web application from World Wide Web [16]. The contents of web 2.0 are participation, sharing, and open; technologies of it are bolg based on RSS, wiki supported collective intelligence, flickr based on user's tag, and RIA(Rich Internet Application)[16]. Flickr is a typical example supported collective intelligence that provides service with users' tags on the pictures; this service helps user search proper photos. Another example is RIA, it is web application that has a function and a feature of application program on desktop. That is, it is an application program that does not need to refresh in a page on WWW[17].

Therefore, we developed the PVR system based on web 2.0. It allows easily users write their feeling and information about a heritage on learning contents of PVR.

2.3. TAM (Technology Acceptance Model)

TAM has been used to investigate which factors affect users' usage of new technology. Based on the model, three types of perceptions (i.e., ease of use, usefulness, and attitude) influence the actual use. These perceptions were used to determine the different effects of four multimedia content types on grade levels and gender. TAM explains how people accept a new system.The model argues that a technology's ease of use and usefulness determine an individual's intention to use the system [18]. The perceived ease of use and perceived usefulness have an impact on positive attitudes and directive usage of information technology [18]. TAM has been adopted by many studies to investigate actual system use in regard to users' perceptions [19-21].

3. System Design and Implementation

3.1. Overview of PVR System

Prior to this study, we developed the PVR system for heritage learning. The architecture of the system and e-book content are shown as Figure 1.

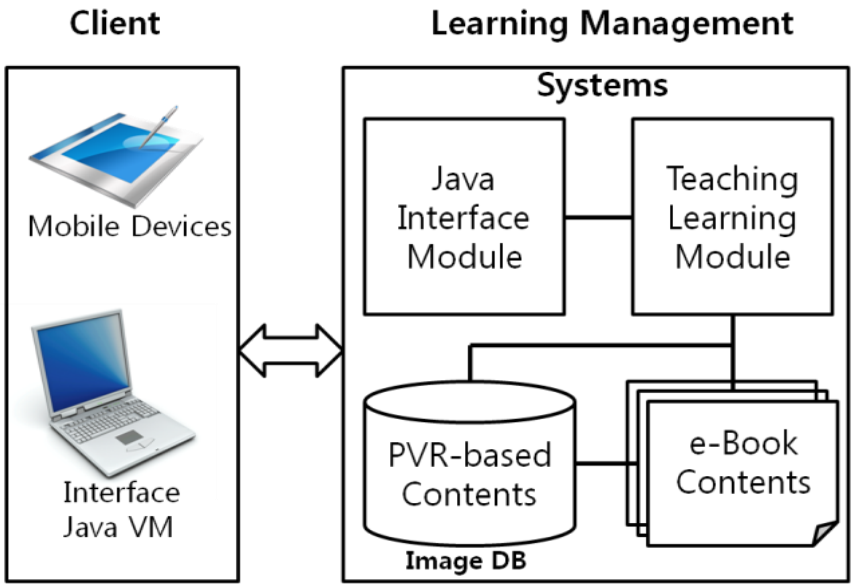

Figure 1. The Architecture of Previous PVR System

Collected heritages were selected from heritages in the society and Korean history textbook from third grade to ninth grade. The system consists of data module and learning management module: data module has heritage contents based on PVR and image database, learning management module manages learning history and delivers learning contents to learner. This VR system does not need other hardware; learner can use it by installing plug-in or JAVA virtual machine. Therefore, learner can use it on mobile device or desktop PC that has plug-in or JAVA virtual machine simply.

The steps of PVR work are taking a picture of heritage, stitching, and VR work. First, we took a picture of Korean heritages with a special table tripod and a digital single lens reflex camera. Collected heritages were selected from heritages of Kyonggi province in Korea that were in the list of cultural heritage administration and in the society and Korean history textbook from third grade to ninth grade. Next, we stitched the pictures of heritages by Stitcher 6.0 of Realviz. The stitched images were made in the form of panorama by panorama tool of Photoshop plug-in. We removed unnecessary parts from the stitched images like as table tripod and camera, and recovered original ground. We used Tourweiver program of Easypano for making virtual reality contents; it was constructed in virtual reality space and passing route. Tourveiwer can make PVR environment on web browser based on JAVA, and hotspot function supported a hyperlink from the point to another point and audio guidance about the heritages. After working of virtual reality, we categorized the heritages into grade, subject, and region for managing the contents in database effectively. The final form was e-book by Flash, and capable contents on mobile devices (notebook, PDA, tablet PC) or desktop PC. Figure 2 shows basic information, learning contents, pictures of heritages; the contents connected to VR learning contents by hyperlink.

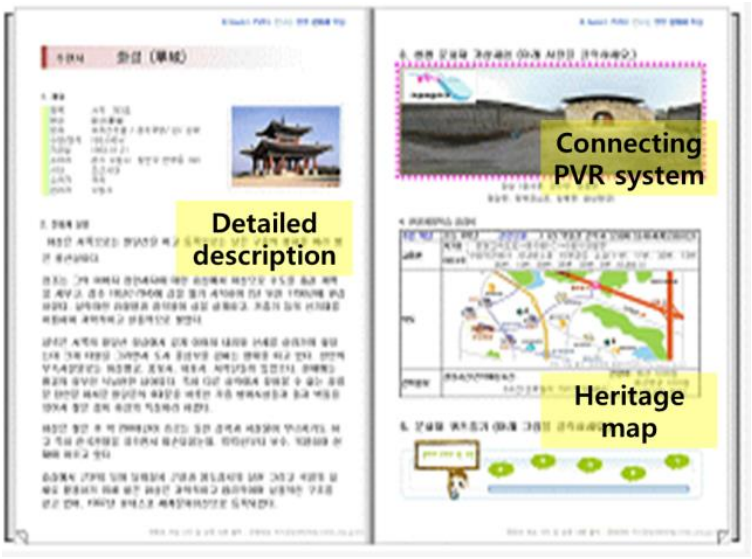

Figure 2. Learning Contents of e-book Form

3.2. Development of Web 2.0 PVR System

As mentioned above, simple PVR learning environment is insufficient to active learner focused learning, so we revised previous PVR system and developed web 2.0 PVR system for learning about heritages shown as Figure 3.

The system provides PVR learning contents and collaborative space to learners. We used some tools and database system: Flash, Flex, PHP, Mysql. The features of this system are inserting tags on the picture of heritages like as Flickr, sharing their information, learners' thinking, or feeling about heritages. When learners study the contents of heritage on PVR system and occur their thinking about a part of heritage, they can stick the pin on a certain part of the VR viewer and write their thought on the message board. The message is connected to pin, so learners click the pin and see the message. Also, the pin is able to move by drag and drop. As previous PVR system, learners only viewed contents of heritages and wrote their thinking on web board, but they were not connected and learners could not write on a certain part of PVR contents. However, this system provides web 2.0 service to learners.

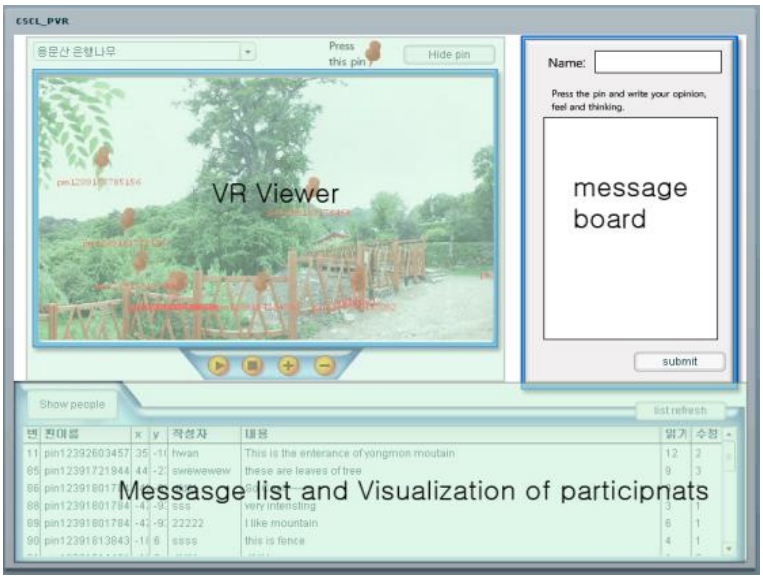

Figure 3. Screenshot of Web 2.0 PVR System

For example, one learner sticks a pin and writes message another and learner clicks the pin and read the message and they can correct the message to the right side like as wiki. When learners click the pin or the message; the pin's colour changes to green and learners recognize it easily. Learners can select a visible pin or an invisible pin for usability. For application of RIA technology, each module communicates with server for data communication not refreshing page. In particular, a part of PVR is made by Flash Actionscript does not need to communicate with server. So, it can be data processing quickly. The list of heritage is made by xml shown as Figure 4; it can expand by user controlled list shown as Figure 5.

```
<?xml version="1.0" encoding="euc-kr" ?>
<Picture Gallery>
<Picture>
<description>Ginkgo of Youngmun mountain
</description>
<name>./6 grade/20 GinkgofYoungmun.jpg
</name>
</picture>
<Picture>
<description>Dolmen of Chonamri
</description>
<name>./6 grade/23DolmenofChonamr.jpg
</name>
</Picture>
</Picture Gallery>
```

Figure 4. Source Code of XML

Figure 5 shows the list of message, it connect PHP file and web database, and restore and load the data. When learner write or correct the message, it restore in web database immediately. List refresh button supports to load the new message without refreshing page.

First of all, this system provides visualization of participant rate of learners for recognizing circumstance of learning like as Figure 6. If learners click other human icon, the human icon moves forward and shows information: participant's name, number of message about a heritage, participant rate. More participant write a message, more the red bar is longer.

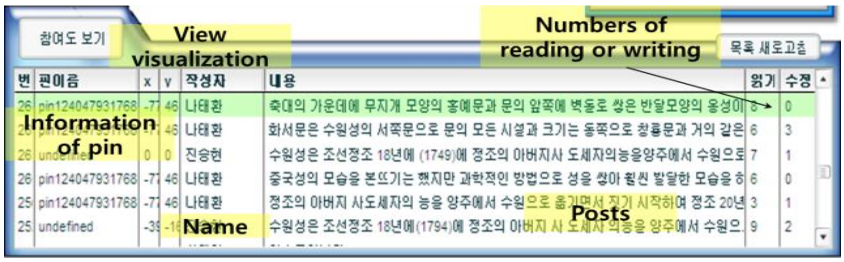

Figure 5. Message List (Korean Version)

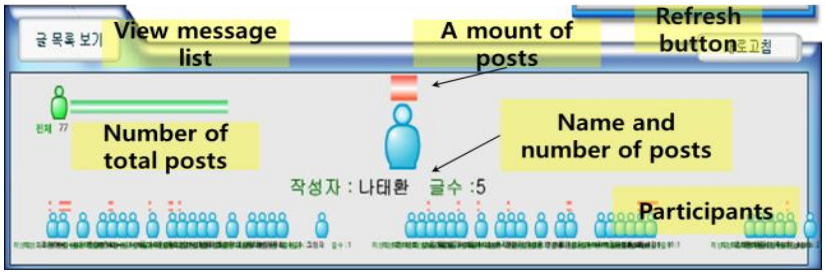

Figure 6. Visualization of Participants (Korean Version)

4. Experiment

4.1. Experiment Design

A total of 68 students from two elementary school classes participated in a field test. The treatment group had learned on web 2.0 PVR, while the control group had learned on normal PVR system. For assuring their homogeneous, we divided two groups from one class and took the sum of each group for statistics. According to the research question, we analyzed a learning effectiveness, a participation rate, the perception about web 2.0 PVR, and TAM analysis(Figure 9).

The questionnaires were selected from collaborative learning research [19-22]. We selected an expert collaborative learning model for heritage learning on web 2.0 PVR. In the case of heritage learning, there are huge contents and various heritages, so an expert collaborative learning model is appropriate. There were two lessons; the contents of lessons were about Hwaseong Fortress of world cultural heritage(shown as Table 1).

Table 1. Learning Process of This Research

Step	Learning Activity	Consideration
Preparation	Learning preparation Making teams Learning how to web 2.0 PVR	
Planning and learning	Introduction of learning step Selecting an expert position of original team Each experts learn Come back to original team and learning	Using web 2.0 PVR system
Sharing	Sharing learning contents Evaluation with quiz	
Arrangement	Jointing results and arrangement Evaluation and reflection	Quiz and questionnaire

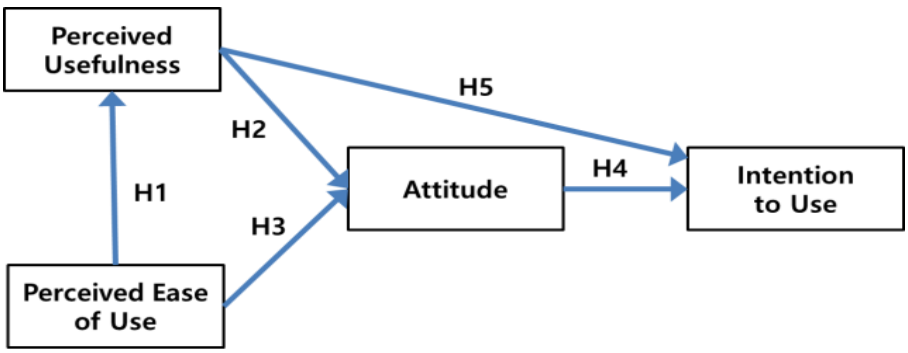

Figure 9. TAM Model

4.2. Results

Because of many missing values, we eliminated 11 data and analyzed a perception about learning, interaction and learning effectiveness with 57 data by SPSS 16.0.

Also, we used a multiple regression for TAM analysis.

First, the result of a perception about collaborative learning showed no significant difference. The main reason is that the learning period is short and participants may not understand the means of sharing and collaboration.

Second, the number of reading messages that is a practical criteria of collaborative learning showed significant difference (t = 3.019, p = 0.004). Although the result of writing activity was not significantly different, the amount of messages in the treatment group was more than the control group. The results of t-test about reading activity showed that web 2.0 PVR learning was more effective(table 2).

Third, the result of the perception that this system facilitates learning is showed in table 3. Students recognized that the web 2.0 PVR system was more effective than normal PVR system for heritage learning (t = 2.532, p = 0.014).

Third, Hypotheses 1 and 3 examine the links between the user's beliefs about perceived ease of use and perceived usefulness and attitude: perceived ease of use is significantly related with perceived usefulness (β =0.784, t-value=6.687, p<0.001) and attitude(β =0.805, t-value=4.514,p<0.001). Therefore, hypotheses 1 and 3 were not rejected.

Forth, Hypotheses 2, and 3 examine the effects of individual's perceptions of the PVR system on the attitude toward using this system. To investigate the hypothesis, entering all variables in a single block, we found that the proposed model explains a significant percentage of variance in attitude (R^2=67%, F-value=27.306, p<0.001).

Table 2. Effectiveness of Web 2.0 PVR System

Factor	Group	N	Mean	Std. Dev.	t	P
Reading	Treatment	30	15.36	12.88	3.019	.004**
	Control	27	7.55	4.02		
Writing	Treatment	30	1.60	1.30	1.650	.105
	Control	27	1.14	.60		

**(P<.01)

Table 3. Effectiveness about Learning

Factor	Group	N	Mean	Std. Dev.	t	P
Helping learning	Treatment	30	4.28	.922	2.532	.014*
	Control	27	3.63	1.070		

*(P<.05)

It is observed that at the 0.001 significance level, perceived ease of use influences user's attitude toward using the system. The positive influences of perceived ease of use

and attitude toward using, as suggested by TAM, are conformed. Therefore, a hypothesis 3 was not rejected.

Fifth, in hypotheses 4 and 5, we investigate the influence of attitude and perceived usefulness on the behavioral intention to use the system. To investigate the hypothesis, entering all variables in a single block, we found that the proposed model explains a significant percentage of variance in attitude (R^2=51%, F-value=14.278,p<0.001). Attitude toward using the system has a significant influence on the intention to use attitude(β =0.490, t-value=2.783,p<0.05). Therefore, a hypothesis 4 was not rejected.

As a result, three hypothesized paths in the model were statistically significant (Table. 4).

Table 4. Results of Hypotheses Tests

Model	R^2	$A.R^2$	β	S.E.	t	result
PU = PEU + errors	.615 [a]	.601 [a]	.784 [a]	.131	6.687	H1 was not rejected
A = PEU + PU + errors	.669 [a]	.645 [a]				H3 was not rejected
PEU			.805 [a]	.197	4.514	
PU			.016	.176	.091	
IU = A + PU + errors	.514 [a]	.478 [a]				H4 was not rejected
A			.490[b]	.165	2.783	
PU			.295	.163	1.673	

[a](P<.001) , [b](P<.05)

5. Conclusion

In this study, we develop a web 2.0 PVR system that grasps collaborative learning activities. Also, by applying the developed tool to a practical lesson, we verified perception, effectiveness, and easiness when using through a questionnaire. In this study, we experimented with 68 elementary school students. The results clearly show that this system is useful to help learners' interaction and VR learning. In addition, TAM analysis shows that ease of use and attitude are main factors for using this tool frequently.

Therefore, if we apply this PVR system to collaborative learning, we are able to facilitate learners' participation and communication, and increase effectiveness of teaching and learning. Using this tool, a teacher can play a role of a guider and a supervisor of the collaborative learning and students can help each other. From the point of applying this system to educational field, there are some advantages:

- This system helps that teacher can observe students behavior on the learning system, so teacher can give an appropriate feedback to students.
- This system facilitates participation of students and their self-directed learning due to applying some advantages of web 2.0.
- This system can be used in any platform because it is based on the web.
- This system supports to share information of learning contents for field trip

In the case of evaluative individuals or groups after learning, it provides a teacher with exchanged messages and grade of learning participation easily. After finishing this study, we will apply this result to a three-dimensional VR learning.

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