Virtual Experience Learning Systems A Survey

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***Abstract*— This paper is a survey of virtual experience Learning Systems. The author surveyed 14 research results of virtual experience learning systems and compared them based on case analysis criteria, considering the technical characteristics of learning systems. The criteria include operational equipment used, location in the continuity between real world and virtual world environment, and interaction according to user participation type.**

***Keywords*— Virtual Reality; Virtual Experince; VR Llearning**

I. INTRODUCTION

With the development of computing technologies and various media using new technologies, it is easy to expect that a new learning method to replace books will emerge. In particular, virtual reality including augmented reality or mixed reality has received high attention as a new educational medium. This is because the virtual learning environment can provide learners with more experience-based education. The experiential learning method enhances the learners' immersion and interest. As a result, this learning method not only enhances the learning achievement but also plays an important role in improving the learners' satisfaction. Based on this background, many virtual reality research institutes have been studying learning systems capable of virtual experience, and some of them have been utilized in actual education field. However, most studies are still in the early stages or experimental stages, and more systematic research is needed for the virtual experience learning to become a formal curriculum for public education.

In this study, the survey was conducted to analyze the virtual experiential learning systems more systematically. The results of 14 studies, which have been evaluated as relatively successful results, were analyzed and compared. The analysis criteria are set to three in consideration of the technical characteristics of each learning system, which include operational equipment used, location in the continuity between real world and virtual world environment, and interaction method according to user participation type.

This paper is organized as follows. In Chapter 2, we begin with an explanation of the analytical criteria we have set. Chapter 3 introduces 14 research results, and chapter 4 summarizes 14 research example. Finally, in Chapter 5 describes the conclusion and future trends of the virtual experience learning system.

II. CASE ANALYSIS CRITERIA

Prior to analyzing the cases of the virtual experience learning system, the criteria were set according to the technical characteristics used by the virtual reality system as follows.

A. Operational Equipment

The manner of providing the 3D visual information depends on the operating equipment. In addition, available virtual experience-based technology factors also depend on the type of operating equipment.

1) Mobile: In the form of using a smartphone or a tablet PC, 3D imaging is possible, but stereoscopic imaging is difficult to implement. The use of mobile devices has the advantage of being free to move in various learning places because there is no space limitation. In addition, cooperative learning is *also* possible because it allows natural interaction with other users in a collaborative work space.

2) Desktop: It is a virtual experiential learning that takes place on a general PC. It is possible to utilize the *PCs* that has already been widely used in the field of *public* education, and it has the advantage that the familiar interface can be used although the degree of immersion is low.

3) Immersive: It is composed of a large screen and a projector. It is easy to realize stereoscopic images by *using* special glasses, and various virtual reality devices such as a tracker can be used. The degree of immersion is higher than other systems, but it is difficult to design a collaborative work space, and there is a disadvantage in that the cost of implementing the system is the highest as well as space limitation.

4) HMD: It is mainly composed of a combination of a head tracker capable of tracking the direction of the head, and recently, head-tracking fuction has been built in. Although it has a disadvantage that it is expensive and has a tendency to cause cyber-sickness most easily, recently, products such as Oculus and Vive have been released intensively, with many of the disadvantages improving and prices dropping a lot. Nowadays, virtual experience system using HMD is the most studied.

B. *Mixed Reality*

It can be divided into 3 types as follows according to the degree of blending of the 3D image generated by the virtual reality technique and the real world image. This distinguishes the degree of mixture in the continuity of the real world environment and the virtual world environment [1].

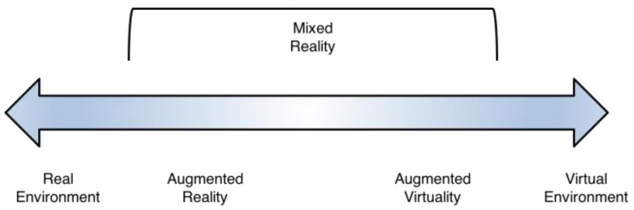

Fig. 1. Continuity between real and virtual environments

1) Virtual Reality: Only computer-generated 3D images are used without using real images.

2) Augmented Virtuality: It improves the reality by composing real world objects based on virtual environment. It is implemented in such a way that a real person appears in a computer-generated 3D image or a real-life object is inserted. In the case of multi-participant learning contents, the image of the teacher or the opponent is acquired directly from the camera. The technique of extracting the desired object from the real image such as blue screen and the matching technique (registration) between the extracted image and the virtual environment are necessary.

3) Augmented Reality: It puts virtual objects in real images. The real image from a camera is mainly used as a background environment and the object to be interacted with is created by a computer. You can use the learning site as it is and interact with a real object by touching it directly. Just like this, doing physical interaction with the hand is also called TUI (Tangible User Interface).

C. *Interaction*

Interaction can be divided into one participation type and multiple participation type, and multiple participation can be divided into two according to the difference of physical space. Multi-participatory learning enables more effective education by enabling natural interaction between students or between students and teachers

1) HCI: One-person interaction with a single computer is commonly referred to as human-computer interaction (HCI).

2) Shared Space: The concept of a shared workplace such as a kiosk that anyone can use in public places such as museums and exhibition halls. It is also possible to use cooperative learning to share physical space and share roles with each other by using a mobile device such as a smartphone.

3) CSCW: It is called computer supported cooperative work (CSCW) as it enables many-to-many real-time interaction (multi-user interaction) via networking technology from a remote location.

III. RESEARCH CASES

A. *HELLO (Handheld English Lanugage Learning Organization) [2]*

1) *Operational Equipment:* Mobile-
2) *Mixed Reality:* Augmented Reality
3) *Interaction:* HCI
4) *Learning Topic:* English
5) *Technical Chracteristics:* PDA, Barcode, Wi-Fi

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This system is a barcode-based context-aware learning system. A user looks at the map on the screen of a PDA and finds the barcode installed all over the campus. When the camera of the PDA recognizes the bar code, the corresponding learning contents are downloaded from the server through wireless network. Learning activity mainly conducted by an English conversation with a virtual learning partner (VLP), which is rendered in 3D with augmented reality technology.

B. *See (Shrine Education Experience) [3]*

1) *Operational Equipment:* Desktop
2) *Mixed Reality:* Virtual Reality
3) *Interaction:* CSCW
4) *Learning Topic:* Culture, History
5) *Technical Chracteristics:* DVE

This system is a typical networked virtual reality system (or DVE: Distributed Virtual Environment) in which people from all over the world can participate in 3D virtual space at the same time. Users can watch and interact with avatars representing themselves by freely navigating in 3D space, and can also use the dialog window to discuss with other users. From 2002 to 2004, about 1,500 students and teachers have participated.

C. *Osaka-DVE [4]*

1) *Operational Equipment:* Desktop
2) *Mixed Reality:* Virtual Reality
3) *Interaction:* CSCW
4) *Learning Topic:* Engish
5) *Technical Chracteristics:* DVE

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The project has developed a system for learning English in a large-scale networked virtual environment where many people can participate at the same time. Students learn by talking in English with a given topic in 3D virtual space. The implication of this system is that students are able to communicate more positively than when they learn in real physical environments, such as when users are more active in expressing their opinions in cyberspace.

D. *Construct3D [5]*

1) *Operational Equipment:* HMD
2) *Mixed Reality:* Augmented Reality
3) *Interaction:* CSCW + Shared Space
4) *Learning Topic:* Geometry
5) *Technical Chracteristics: DVE*

Construct3D is a system in which users who wear HMDs learn Geometry through a geometric object that is rendered by augmented reality technique. Based on the networked virtual environment, users can share the results of interaction with each other, and can share the physical work space, so that cooperative learning is possible. This project was actually applied to the education at a elementary school, showing the augmented reality technology was mature enough to be applied to the public educational environment right away.

E. One-on-one Digital Engilish Classroom (DEC) [6]

1) *Operational Equipment:* Mobile-
2) *Mixed Reality:* Virtual Reality (2D)
3) *Interaction:* HCI
4) *Learning Topic: English*
5) *Technical Chracteristics:* Voice Recognition

It is a system that teaches English by using traditional 2D GUI based contents rather than 3D images. It is designed for elementary school students, and students learn by expressing themselves in English by looking at the problems submitted by the PDA. As a result of field application, passive students showed active learning attitude.

F. COLLVIRS [7]

1) *Operational Equipment:* Immersive + Desktop
2) *Mixed Reality:* Virtual Reality
3) *Interaction:* HCI + Shared Space+ CSCW
4) *Learning Topic:* Culture
5) *Technical Chracteristics:* DVE

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The feature of this system is that it is designed to enable all 3 types of interactions, such as HCI, shared space, and CSCW. In front of the classroom, a virtual environment presented by a teacher on a large screen is rendered, and each student can freely move virtual space on a personal PC. In addition to traditional learning methods between teachers and students in the collaborative work space, virtual experience learning is also performed in shared virtual space.

G. LBD(LearningBy Doing) [8]

1) *Operational Equipment:* Immersive
2) *Mixed Reality:* Real Environment + Virtual Reality(2D)
3) *Interaction:* HCI
4) *Learning Topic:* English
5) *Technical Chracteristics:* Ultrasonic Reciever & Tag

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In this project, they installed a large number of ultrasonic receivers on the ceiling of a special room and attaches ultrasonic tags to objects and users in the room. When a user moves, the system recognizes the location of the user and also recognizes objects around the user. Educational contents are provided according to the user's location and surrounding objects, and the user learns English while performing actions. It is more educational than passive learning because a student learns by acting directly with the body.

H. Hellas Alive [9]

1) *Operational Equipment:* Desktop
2) *Mixed Reality:* Virtual Reality
3) *Interaction:* CSCW + HCI
4) *Learning Topic:* Greek
5) *Technical Chracteristics:* DVE

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It is a system that can teach Greek. It is an integrated form that allows users to explore the Greek city built in a 3D virtual environment or perform traditional 2D GUI e-Learning. Multiple participation is possible so that cooperative learning is also possible between students or between students and teachers. It can be downloaded directly from http://www.hellasalive.gr.

I. Location-Based Interaction (LBI) [10]

1) *Operational Equipment:* Immersive
2) *Mixed Reality:* Virtual Reality
3) *Interaction:* Shared Space
4) *Learning Topic:* General
5) *Technical Chracteristics:* RFID, Agent, LBS

The biggest drawback of an immersive systems with a large screen is that multiple users can not use the system at the same time. This system uses RFID technology to enable users to collaborate in a shared workspace without using additional devices. Two agents are appeared in two immersive environments, and the flow of learning scenarios vary according to the users' location.

J. Gulliver's World [11]

1) *Operational Equipment:* Immersive
2) *Mixed Reality:* Augmented Reality + Augmented Virtuality + Virtual Reality
3) *Interaction:* Shared Space
4) *Learning Topic:* Gemera;
5) *Technical Chracteristics:* Chroma Keying

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This system can not be located only at one point in the Milgram's proposed continuity between real environment and virtual environment [1]. They attempted to break the boundary among augmented reality, augmented virtuality, and virtual reality. Users can participate in collaborative learning by using augmented reality contents, and participate in contents directly by using the chroma-keying technology.

K. Alien Contact [12]

1) *Operational Equipment:* Mobile
2) *Mixed Reality:* Augmented Reality
3) *Interaction:* Shared Space
4) *Learning Topic:* Math, Language
5) *Technical Chracteristics:* PDA, GPS

This project is a collaborative research project between the Harvard Graduate School of Education, the University of Wisconsin at Madison, and the Teacher Education Program at MIT, supported by the US Department of Education. The goal is to develop a learning system that is implemented by augmented reality technology using a handheld device equipped with a global positioning system (GPS) and to study its effectiveness. In 2004, this project has started and is ongoing. This system is applied to 8th grade students in middle school, and the contents developed are mathematics and language.

In 2006, a pilot test was conducted for students and teachers at Boston High School. All teachers and students participated in the program announced that they were more engaged and a lot involved. They also emphasize the need to solve practical issues such as cost-effectiveness, and to strengthen interactivity and collaboration.

L. Savannha Project [13]

1) *Operational Equipment:* Mobile
2) *Mixed Reality:* Augmented Reality
3) *Interaction:* Shared Space
4) *Learning Topic:* Ecology, Ethology
5) *Technical Chracteristics:* PDA, GPS, Wi-Fi

Savannah Project has been participated by Mobile Bristol, BBC, and Futurelab since 2003, and the research and development of the prototype is completed. As a strategic simulation, Savannah is also an adventure game in a virtual space associated with the real world, where a child takes on the role of a lion living in Savannah and explores the augmented reality environment with a mobile handheld device.

This project has provided a strong incentive for students' involvement and engagement by integrating augmented reality, wireless mobile communications, and gaming technologies to provide opportunities for collaborative, reflective, and creative learning in Ecology and Ethology.

M. wIzQubes [14]

1) *Operational Equipment:* Desktop
2) *Mixed Reality:* Augmented Reality
3) *Interaction:* Shared Space
4) *Learning Topic:* Storytelling
5) *Technical Chracteristics:* None

This system was developed by the Mixed Reality Laboratory at the National University of Singapore and the MXR Corporation. It is a project that aims to develop and commercialize wIzQubes, a bi-directional storytelling book using a new type of tangible interface. It started in 2004.

Different stories are unfolded according to how to manipulate (Rotate, Turn, Match, Behold) cube-shaped toys. and two cubes are arranged side by side. When two cubes are arranged side by side, two 3D animations.

N. Augmented Story Book

1) *Operational Equipment:* Desktop
2) *Mixed Reality:* Augmented Reality
3) *Interaction:* Shared Space
4) *Learning Topic:* Language
5) *Technical Chracteristics: None*

This project, which is being studied and developed by Human Interface Technology Laboratory New Zealand (HIT Lab NZ, University of Canterbury), is an extension of the eyeMagic Book developed in 2004. The purpose of this study is to analyze the degree of improvement of reading ability and to observe experience on augmented reality applications.

IV. SUMMARY

In most development cases, augmented reality technology has been used as a substitute for supplementing learners' leading participation and sensory immersion that can be easily lost in traditional learning environments. Particularly, in terms of economic efficiency, 2D user interface such as desktop and mobile device is recycled. In terms of learning content design, they mainly feature intent, flexibility, and single-user interaction.

It has been shown that the number of attempts to utilize the head mounted display (HMD) or to develop a separate tangible interface is increasing. These types of systems are developed in the form of "field experience-based learning" in which behavior and introspection occur at the same time by supporting multi-user interaction such as sharing of augmented reality experience at a remote place by basically combining with networking technology. In addition, real-time integrated design of on-site experience learning and classroom learning is becoming possible by networking with indoor augmented reality technology. The characteristics of the 14 projects are summarized in Table I.

TABLE I. SUMMARY OF 14 PROJECTS

Project	Equipment	Mixed Reality	Interaction
HELLO	Mobile	AR	HCI
SEE	Desktop	VR	CSCW
Osaka-DVE	Desktop	VR	CSCW, SP
Construct 3D	HMD	AR	HCI
One-on-one DEC	Mobile	VR (2D)	HCI, CSCW, SP
COLLVIRS	Immersive, Desktop	VR	HCI
LBD	Immersive	Real, VR(2D)	CSCW, HCI
Hellas Alive	Desktop	VR	SP
LBI	Immersive	VR	SP
Gulliver's World	Immersive	AR, AV, VR	SP
Alien Contact	Mobile	AR	SP
Savannah	Mobile	AR	SP
wIzQubes	Desktop	AR	SP
Augmented Story Book	Desktop	AR	SP

V. CONCLUSION AND FUTURE TRENDS

The virtual learning environment has been evaluated as having various educational potentials. However, it is criticized that the majority of the related researches carried out tended to focus mainly on how to apply them in terms of technology. In addition, there are many cases where the application environment is distant from the actual learning environment. In other words, there is a lack of discussion as to what kind of demands are in terms of actual teaching-learning and which design method is appropriate.

As a next generation learning technology, virtual experience learning is expected to play a very important role in education. Demand will increase not only in regular classes at elementary and secondary schools but also in community learning environments such as museums, heritage sites, and cultural centers. Furthermore, if we anticipate the age of lifelong learning, the potential demand for virtual experience learning will be very large. Given these educational needs, technology development and research on virtual experience learning will be more active in the future.

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