Challenges and Issues in Building Virtual Reality-Based e-Learning System

Marwa A. Abdelaziz[1*], Alaa El Din M. Riad [2], M. Badr Senousy [3]

[1, 3] Sadat Academy for Management Sciences, Cairo, Egypt.
[2] Faculty of Computer Sciences and Information Systems, Mansoura University, Mansoura, Egypt.

* Corresponding author. email: marwa.abdelaziz@sadatacademy.edu.eg
Manuscript submitted August 8, 2014; accepted August 29, 2014.
doi: 10.7763/ijeeee.2014.V4.347

Abstract: E-learning is a new teaching model nowadays. It gets further development and improvement with the impetus of the Virtual Reality (VR) technology, which can build a friendly human machine interface. VR is becoming increasingly important as a learning tool in the schools as well as in universities, due to its interactive and animated features. VR can be an effective method for teaching and reinforcing complex concepts by allowing students to interact with the visualization tools. The pattern which integrates the VR and e-learning technology not only riches teaching patterns but also improves learners' ability of analyzing and solving problems. The virtual learning environment provides a new study method for students to understand certain events which have proven inappropriate and difficult in traditional education. This paper highlights and discusses the issues and challenges associated with implementing a virtual reality based e-learning environment. It explores educational uses of an e-learning environment in combination with VR technology.

Key words: Virtual worlds, virtual reality, e-learning, desktop virtual reality.

1. Introduction

Education has moved on from books, pencils and pens to the use of interactive technologies to help impart knowledge and understanding. E-learning technology can't solve all problems that exist in traditional education although it improved traditional teaching techniques.

E-learning platform in combination with technologies such as information, multimedia alters the traditional learning style and learning environment. Teachers can deliver a lecture at anytime and anyplace. E-learning changes the relationship between teachers and students in traditional education and provides a platform for students and teachers to communicate. Students can do cooperative study through the platform [1].

The major concern of educators is how to enhance the outcome of education. Effective education media used to assist teaching have been constantly sought by the researchers in educational technology. Virtual Reality (VR) has been identified as one of them.

There are several ways in which VR technology is expected to assist learning. It allows students to visualize abstract concepts, to observe events at atomic or planetary scales, and to visit environments and interact with events that distance, time, or safety factor make unavailable. The types of activities supported by this technology promote current educational thinking that students are better able to master, retain, and generalize new knowledge when they are actively involved in constructing that knowledge in a hand on

learning environment [2].

The rest of this paper is organized as follows: in Section 2, we introduced the application of virtual reality both in Education and e-education. We will introduce Software tools for VR application development in Section 3. In Section 4 challenges and work directions are illustrated. Conclusions are given in Section 5.

2. Virtual Reality

VR has been defined as a highly interactive, 3-D computer generated program in a multimedia environment that provides an immersion effect to the users. It enables humans to directly interact with computer generated environments that simulate the physical world. VR is now used as an aid of teaching and practice in a wide range of fields such as engineering, medicine, design, architecture and construction, education and training because it can provide major improvement and can be really effective [3].

VR can be categorized into two main types based on the level of interaction and immersive environment.

Immersive VR environments are presented on various, room-size screens or through a stereoscopic, head-mounted display unit. Special hardware such as gloves, suits and high-end computer systems might be needed in an immersive VR environment.

In non-immersive VR, computer simulation is represented on a traditional personal computer and interaction with the virtual environment is done using keyboard, mouse, joystick, or touch screen [4].

2.1. VR Based Education

Some abstract concepts are still very difficult for students to comprehend because there are no entities to display to them. VR technology just makes up for the shortcomings of e-learning. It can simulate experimental equipments and offer a virtual experiment environment for students. And students can interact with the virtual environment via input devices, such as mouse, keyboard. Teachers can make up virtual objects or abstract scenery by VR technology to offer a stimulating and interesting learning way for students [1].

Three approaches to education can be referred: full-time education, part-time education (part at school, part virtual or at a distance) and distance education (virtual) as seen in Fig. 1. Face-to-face or full-time education is the conventional type of education and the most widely used approach in normal courses at any level, requiring teachers and students to be together in the classroom. The second approach combines learning in the classroom and at a distance using modern technology. Distance education may or may not need to have face-to-face moments as teachers and students are physically separated in space or in time, while being able to interact through communication technologies, i.e. virtually [5].

The virtual reality environments which are designed specifically for education typically fall into three categories as shown in Fig. 1. The first includes networked text-based virtual environments, which are highly interactive but not immersive. The second involves desktop virtual reality simulations, where interactivity is usually limited but varies according to the control given by the program, and immersion also varies but is not easily provided. The third category includes the immersive VR environments, where immersion is high, but interactivity may be limited, depending on the complexity of the virtual world.

2.1.1. Networked text-based virtual worlds

Text-based virtual worlds are real-time multi-person virtual environments created through text descriptions rather than graphics. These environments are commonly known as MUDs, or Multi-User Dungeons. These text-based virtual environments were primarily designed for entertainment, but an increasing number of MUDs and MOOs now exist for education. One of the earlier ones is ExploreNet, a networked virtual world where children interact with each other via avatars in settings filled with

computer-controlled props. ExploreNet employs a story-like two-dimensional graphical interface to combine networked use of text and graphics.

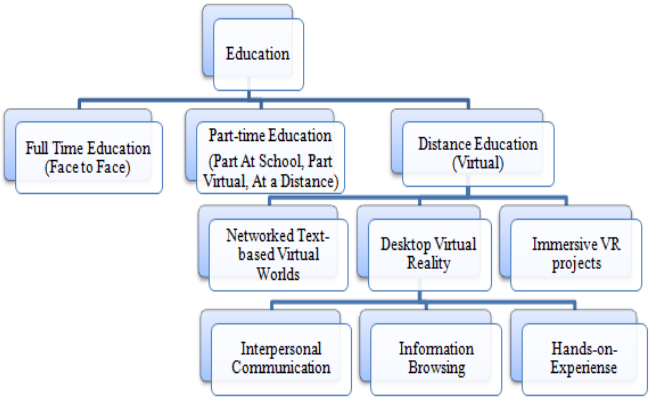

Fig. 1. Approaches of education [5].

2.1.2. Desktop virtual reality

Classroom uses of virtual reality are limited, primarily due to the high cost of VR systems. For this reason, the term ``virtual reality'' has been applied more widely to include desktop virtual reality. VR applications on the personal computer allow users to walk through simulated environments created via readily available commercial software, such as Virtus WalkThrough.

Desktop VR is a cheap and widely available solution, and is easily adopted by teachers and students without expensive equipments. Therefore, desktop VR is a suitable educational tool in the classroom. Up to date, more and more desktop VR systems have been developed in educational domain. The authors in [4] divided desktop VR systems into three types according to their main operations as seen in Fig. 1. The three types are interpersonal communication, information browsing and hands-on experience.

Table 1. Some Desktop VR Systems in Education

System name	Type*	Instructional method	Target users
Active Worlds	I	User builds the world what they want and system provides social interaction functions	High school and college students, adults
Virtual European School (VES)	I	A 3D community that provides educational material, communication and multi-user interaction	Secondary school students
Virtual Museums, MoMA, Metropolitan Museum	II	360° virtual tours of each exhibition room and architectures of the museums	Masses
Physics Education Research (PER)	III	Provide VR labs to probe physical laws such as liner motion, circular motion and collisions	High school students
Virtual Reality Physics Simulation (VRPS)	III	Provide VR labs to probe science such as wave propagation, ray optics, relative velocity, electric machines, etc.	High school and college students
Virtual Radioactivity Laboratory	III	Provide VR labs to probe radioactivity	College students
Web Talk-I & II	I, II	An expert or an automated avatar guides users to view the exhibitions in real time. Users can discuss with the expert and other users during virtual tours	Masses
Shrine Education Experience (SEE)	I, II, III	Develop a museum virtual world, and provide socializing and manipulation in the virtual world	High school students

* **Type I**: Interpersonal communication, **Type II**: information browsing, **Type III**: hands-on experience

Each type can be applied to the different demands of subject domains. For example, science teachers may expect students to learn by doing whereas art teachers may expect students to watch and appreciate a lot of paintings. Therefore, functions of hands-on experience and information browsing may be suitable for these

two needs. Table 1 lists some of famous desktop VR systems in education [4].

An example of Hands-on-experience desktop VR system is the Virtual Reality Physics Simulation (VRPS). It helps students to learn physics concepts such as wave propagation, ray optics, and relative velocity at the level of high school or college physics. The VRPS provides a sensory-rich interactive learning environment which enhances students' understanding by providing a degree of reality which is unable to be achieved in a traditional 2-D interface. VRPS is a useful teaching tool for highly interactive visualization of abstract concepts in physics education.

2.1.3. Immersive virtual environments

Immersive educational environments are being developed using high-end equipment. They are consequently limited to situations with special funding, such as academic and research environments. Most of the projects are developed especially for head-mounted display systems (HMD).

An example of Immersive educational environments is Construct3D. It is a 3-D geometric construction tool based on the collaborative augmented reality system Studierstube. The setup uses a stereoscopic HMD and a Personal Interaction Panel (PIP), a two-handed 3-D interaction tool. It is used in mathematics and geometry education [6].

Another example is NICE (Narrative-based, Immersive, Constructionist/Collaborative Environments). It is one of the first educational VR applications designed and developed for CAVE by the Electronic Visualization Lab (EVL) at the University of Illinois at Chicago. NICE is a system that supports real-time distributed collaboration. The children can collaboratively construct, plant and tend a healthy virtual garden, learn about gardening and work together [7].

2.2. VR Based e-Education

Zahira Merchant et al [8] discussed the effectiveness of virtual reality-based instruction on students' learning outcomes in K-12 and higher education. They used meta-analysis is to examine overall effect as well as the impact of selected instructional design principles in the context of virtual reality technology-based instruction (i.e. games, simulation, virtual worlds) in K-12 or higher education settings.

M. Travassos Valdez *et al*. [9] used a desktop virtual reality system for distance education. Min Jou *et al.* [10] discussed investigation of effects of virtual reality environments on learning performance of technical skills.

Hazar Dib *et al.* [11] made An Interactive Virtual Environment for Teaching "Triangulations and Coordinates Calculations" to Surveying Students.

Shaoliang Qi *et al.* [12] proposed a novel e-learning hypothesized learning platform based on VRML-Java. It describes the characteristics and complementary of VRML and Java language and elaborates the architecture of the virtual learning system.

Shaojing Fan *et al.* [13] designed a model of virtual reality environmental education.

Elinda Ai-Lim Lee *et al.* [14] examined how desktop virtual reality enhances learning outcomes.

Fengming Yang *et al*. [1] represented the important role of VR technology in e-learning through a virtual physics experiment built by Java3D which is a top-down approach for building 3D interactive programs.

Zhenbo Li *et al.* [15] build an interactive virtual e-learning environment using virtual reality technologies. With the help of Multi-Modal user interface, students can control their avatars to interactively communicate with virtual teachers and environment.

Elinda Ai-Lim Lee *et al.* [16] explores the possible educational values of VR in relation to spatial ability to call for more research concerning spatial ability in the context of VR based on studies in computer based learning.

3. Software Tools for VR Application Development

In the design of a virtual reality system, the selection of the most appropriate tool is an essential component in the development of a VR program. The level of flexibility and pre-programmed components can vary substantially among software tools [5].

There are number of tools available to the developers of virtual worlds. Some of these are libraries and toolkits, while others are application frameworks, and still others are full development environments, integrating every aspect of the creation of a VR application – modeling, coding, and execution – into a single package. The software components are divided into 3D modeling software, 2D graphics software, digital sound editing software and VR simulation software as shown in Fig. 2 [17].

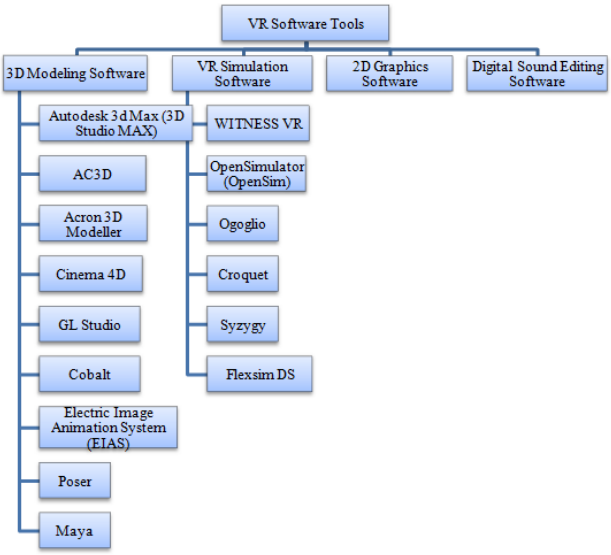

Fig. 2. VR software tools.

4. Challenges and Work Directions

The challenge of teaching students using novel ways and keeping them engaged in theoretical topics has been the most daunting task for educators in Higher Education. The novelty of the use of virtual worlds for education brings with it the challenge of developing pedagogical understandings around the relationship between the use of synthetic experiences and the educational context within contemporary society [18]. Fig. 3 will show the challenges of learning and teaching in 3D virtual worlds.

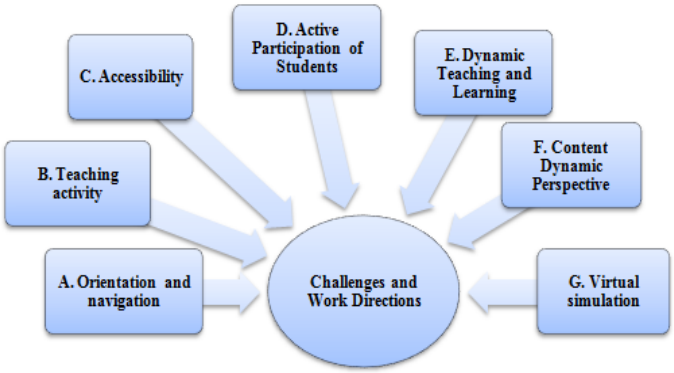

Fig. 3. Challenges and work directions.

4.1. Orientation and Navigation

A study was conducted to investigate the educational use of 3D virtual worlds and found that navigation

and orientation in virtual world is very challenging for first-time users. Students need guidance on how to get around in it, what to do and where to go. So it is essential to give students some guidance on orientation and navigation, including some suggestions on where to go and what to do in the virtual world such as maps [19].

4.2. Teaching Activity

There is a need to indentify the kinds of learning activities that are reasonable and beneficial in virtual environments. Tutors can choose to use different teaching activities in virtual world. Virtual reality based e-learning provides the possibility to offer presentations, tutorials, discussions, building objects, field-trips, and serious game-based learning. The teaching material can be textual, audio or video [19]. Online video tutorials are engaging, informative, and educationally valuable. Students will increasingly experience video tutorial [20].

4.3. Accessibility

Three user groups are concerning accessibility: deaf people, blind people and people who are PCs do not have the computational power necessary to run Second Life smoothly.

The more immersive the online environment gets the more complex it becomes to use. 3D virtual worlds are clusters of technologies (e.g. chatting tools, social networking, game tools, etc.) and if students are asked to use them, they are actually required to use several new pieces of software at once. So an important challenge is that running virtual world requires strong computational power, but many students don't have a computer that is fast enough.

Virtual world is not accessible to blind users. Blind users cannot point with the mouse. The IBM Kestrel blind-accessible virtual world tool makes it possible to access 3D virtual worlds completely by keyboard, and also make it screen-reader friendly.

Considering deaf people and people with hearing impairment, the main issue is the voice chat implemented in Second Life. So it is important to develop a place in virtual world accessible to deaf people that don't require a voice chat [21].

4.4. Active Participation of Students

Active participation of students or learning by doing is a model favored by both students and many educators. As students build and develop their own learning scenarios in virtual reality. Virtual worlds provide a means of creating models of this nature. "Virtual worlds and authentic learning activities foster unintentional learning, where students discover and create knowledge not for its own sake but in order to accomplish something they want to do, resulting in stronger comprehension and deeper knowledge" [22].

4.5. Dynamic Teaching and Learning

Approaching teaching and learning as a dynamic process, where both learners and instructors interact in the same 'virtual world', in the construction of knowledge. Instructors and students alike employ avatars to establish their social presence [23].

4.6. Content Dynamic Perspective

Moving content from a static to a dynamic perspective, changing the lecture-centered relation of classroom teaching to a more student centered one, breaking the old image of the instructor as the only knowledge holder, promoting collaborative approaches to teaching, etc. are some of the challenges they have started to face [18].

4.7. Virtual Simulation

Finding the balance between time consumed (in making objects and scripting) and results obtained is one of the challenges. Virtual simulation is simulating some parts of real life, in quick and efficient ways, particularly the interaction between people and representations of physical objects such as structures, furniture, equipment, vehicles. Simulations can help students build mental models of physical, chemical or biological systems through visualizing concepts that appears on textbooks or hear from their teachers in lectures then they can see a concrete situation that helps them build a mental model. The most common requirements for using simulations are free plug-ins like Flash, Shockwave, and QuickTime. The browser must support Java for some simulations [18].

5. Conclusion

This paper focused on virtual reality's application in e-learning. It's a new area where the possibility of exploring the environments through the objects manipulation scattered in the virtual environment, related to the content to be learned can be seen by student. Some learning activities are hard to perform in a real environment because of high expenses, lack of infrastructure availability or dangerous performance. In virtual worlds it's possible to perform simulations and activities of any kind.

This paper highlights and discusses the challenges and issues of learning in virtual reality such as Orientation and navigation, Teaching activity, Accessibility, Active Participation of Students, Dynamic Teaching and Learning, Content Dynamic Perspective and Virtual simulation.

This study will make a significant contribution in enlightening educators and VR practitioners to the potential of desktop VR technology to support and enhance learning.

References

[1] Yang, F., & Wu., W. (2010). The application of virtual reality in e-learning. *International Conference on e-Business and e-Government, IEEE* (pp. 5548-5551).

[2] Parmar, G. (2013). An impact of teaching through virtual reality based multimedia package on achievement in chemistry subject of students of standard-XI. *International Journal for Research in Education, 2(3).*

[3] Saggio, G., Ferrari, M., & Steenhuis, I. H. M. (2012). *New Trends in Virtual Reality Visualization of 3D Scenarios,* chapter 1.

[4] Lee, E. A. L. (2011). *An Investigation into the Effectiveness of Virtual Reality-Based Learning*, Doctor of Philosophy Thesis, Murdoch University.

[5] Valdez, M. T., Ferreira, C. M., & Barbosa, F. P. M. (2013). Distance education using a desktop virtual reality (VR) system. *EAEEIE Annual Conference (EAEEIE), Proceedings of the 24th* (pp. 145 – 150).

[6] Springer Science & Business Media. (2011). *Handbook of Augmented Reality*. Borko Furht (p. 170).

[7] Parry, R. (2013). *Museums in a Digital Age* (p. 257). Routledge.

[8] Merchant, Z., Goetz, E. T., Cifuentes, L., Keeney-Kennicutt, W., & Davis, T. J. (2014). Effectiveness of virtual reality-based instruction on students' learning outcomes in K-12 and higher education: A meta-analysis. *Computers & Education*, 29–40.

[9] Valdez, M. T., Ferreira, C. M., Barbosa, & F. P. M. (2013). Distance education using a desktop virtual reality (VR) system. *IEEE Conference Publications* (pp. 145-150).

[10] Jou, M., & Wang, J. (2013). Investigation of effects of virtual reality environments on learning performance of technical skills. *Computers in Human Behavior*, pp. 433–438.

[11] Dib, H., Adamo-Villani, N., & Garver, S. (2013). An interactive virtual environment for teaching triangulations and coordinates calculations to surveying students. *17th International Conference on Information Visualisation, IEEE* (pp. 445-450).

[12] Qi, S. (2012). Design and development of e-learning virtual learning system based on vrml and java. *Advances in ECWAC, 2(AISC 149)*, 537–542.

[13] Fan, S., Zhang, Y., & Fan, J. (2010). The application of virtual reality in environmental education: model design and course construction. *International Conference on Biomedical Engineering and Computer Science (ICBECS), IEEE.*

[14] Lee, E. A. I., Wong, K. K., & Fung, C. C. (2010). How does desktop virtual reality enhance learning outcomes? A structural equation modeling approach. *Computers & Education, 55*, 1424–1442.

[15] Li, Z., Yue, J., & Jáuregui, D. A. G. (2009). A new virtual reality environment used for e-learning. *IT in Medicine & Education, IEEE*, 445-449.

[16] Lee, E. A. L., Wong, K. K., & Fung, C. C. (2009). Educational values of virtual reality: the case of spatial ability. *World Academy of Science, Engineering and Technology*, *3*, 991-995.

[17] Onyesolu M. O., Ezeani I., & Okonkwo O. R. (2012). *A Survey of Some Virtual Reality Tools and Resources, Virtual Reality and Environments* (pp. 21-42). from: http://www.intechopen.com/books/virtual-reality-and-and-environments/a-survey-of-some-virtual-reality-tools-and-resources.

[18] Burkle, M. & Kinshuk (2009). Learning in virtual worlds: The challenges and opportunities. *International Conference on CyberWorlds, IEEE Conference Publications* (pp. 320-327).

[19] Pfeil, U., Ang, C. S., & Zaphiris, P. (2009). Issues and challenges of teaching and learning in 3D virtual worlds: real life case studies. *Educational Media International, 46*, 223–238.

[20] Frisbee, M., Anderson-Inman, L., & Rivas, C. (2013). Teaching with avatars: Video tutorials for online learning and digital literacy. *Proceedings of World Conference on Educational Multimedia, Hypermedia and Telecommunications* (p. 1989).

[21] Quirk, P. R., & Conway, T. (2011). Accessibility and distance education. In T. Bastiaens, & M. Ebner (Eds.), *Proceedings of World Conference on Educational Multimedia, Hypermedia and Telecommunications* (pp. 1594-1597).

[22] Gonzáleza, M. M. A., *et al*. (2013). Virtual worlds. opportunities and challenges in the 21st century. *International Conference on Virtual and Augmented Reality in Education* (pp. 330 – 337), Elsevier.

[23] Lawless-Reljic, S. K. (2010). *The Effects of Instructor-Avatar Immediacy in Second Life, an Immersive and Interactive Three-Dimensional Virtual Environment*, Ph.D. thesis, University of San Diego and San Diego State University.

Marwa A.Abdelaziz is a PhD student at Computer and Information System Department, Faculty of Computers and Information Sciences, Mansoura University, Egypt. She obtained her B.S. in information systems from Sadat Academy at 2005 and she received M.SC degree in information system from the Arab Academy for Science and Technology in 2011. Now she is an assistant lecturer in Computer and Information Systems Department at Sadat Academy for Management Sciences, Cairo, Egypt. Her research interests are e-learning, virtual reality, and education technology.

Alaa El Din M. Riad is a professor of computer and information systems at Faculty of Computers and Information Sciences, Mansoura, Egypt. He has received his PhD in electrical engineering in 1992 from Mansoura University, Egypt, and an MS in electrical engineering in 1988 from Mansoura University, Egypt. He has supervised many master and doctorate studies.

M. Badr Senousy is a professor of computer and information systems at Sadat Academy for Management Sciences, Cairo, Egypt. He has received a PhD in computer science in 1985 at George Washington University, USA.