THE VIRTUAL PHYSICS LAB - VIRTUAL REALITY AS A TEACHING TOOL

Nor Azila Awang Abu Bakar, Rusnida Romli and Mohd.Fairuz Shiratuddin

School of Information Technology

Universiti Utara Malaysia
06010 Sintok
Kedah Darulaman
Malaysia

Tel : 04-7003701, Fax: 04-7005753

e-mail: azila_aab@yahoo.com, nida7178@hotmail.com, fairuz@uum.edu.my

ABSTRACT

Virtual reality (VR) technology the third era in the Human-Computer Interaction (HCI) opens a vast opportunity to be applied in the field of education and at the same time support the theory of constructivism. Virtual Reality (VR) system is able to project an entire virtual environment in the computer displaying 3 dimensional elements of sight, hearing and sense of touch (haptic). This paper presents a VR technique to tackle the challenges faced by secondary school Physics' teachers. The `Virtual Physics Lab' is developed and applied as an alternative to assist the current teaching processes. It is foreseen when VR is introduced into Malaysia's educational system, this research will be one of the valuable resources to assist the growth of government's `Smart School' project. Elementary research methodologies, gathering information, prototype design and development and testing, information analysis and documentaries are the steps engaged to accomplish the main research objectives. A 3D Game Engine is used as the tool to develop the prototype system.

Keywords: education, game engine, smart school, virtual reality, virtual lab

Introduction

Virtual Reality (VR) system able to project an entire virtual environment in the computer displaying 3 dimensional elements of sight, hearing and sense of touch (haptic). In the western world countless research coupling the educational system and VR as a teaching tool has been undertaken. VR, therefore has created a new window of opportunity towards assisting and enhancing the educational processes and techniques. In essence, the charateristics of VR itself supports the theory of *constructivism* i.e. to create a `learning-by-doing' atmosphere.

This paper presents a VR technique to tackling the challenges faced by secondary school Physics' teachers. The `Virtual Physics Lab' is developed and applied as an alternative to assist the current teaching processes. It is foreseen when VR is introduced into Malaysia's educational system, this research will be one of the valuable resources to assist the growth of government's `Smart School' project. Furthermore, Loftin (1999) and researchers at the Johnson Space Centre (1999) believe that a new approach in science education is needed. Loftin states,

> *"There are so many people left by the wayside when it comes to traditional science and math education. By the second year of high school, the vast majority of students have lost interest in these subjects, which is a shame."* [5]

One of the main problems in science education is experienced by students when faced by abstractions. Computer visualization tools are particularly effective to overcome this problem[8].

diSessa (1986) states, the trick is not to turn experience into abstractions with a computer, but to turn abstractions like laws of physics into experiences[7].

Recent advances have created new possibilities and the visualization of 3D objects and data becomes increasingly important in learning several scientific subjects (in particular, atomic and molecular science, fluid dynamics, etc.). With virtual reality(VR), the visualization of complex data and the building of more adequate conceptual models is possible[7].

VR has been touted as a powerful teaching and training tool because [7]:

- Supports direct experience of phenomena.
- Is 3D.
- Allow for multiple frames of reference.
- Offers multiscensory communication.
- Is pyhsical immersive.

A highly regarded article by Stuart and Thomas published in 1991 lists 7 roles for VR in education:

- Exploring places and things students would not otherwise have access to

- Exploring real things that, without changes to scale in size and time, couldn't be examined
- Creating places and things with altered qualities, such as Earth during the ice age
- Interacting with people who are in remote locations
- Interacting with people in nonrealistic ways, such as flying
- Learning abstract concepts in math and science
- Interacting with virtual beings, such as representations of historical figures

Pantelidis(1999) said, VR should be used to teach subjects for which standard lessons might be dangerous, harmful to the environment, or costly [5].

Virtual Physics Lab

Physics was always an area in which we had a lot of what if's. While trying desperately to comprehend such enticing topics as gravity, moments of inertia, complex interactions between colliding objects and a hundred other concepts, we knew that if we could visualize what was going on, we'd have reasonable time of understanding it [1].

VR lab obtained from the review done by using 2D approach for example those produced by University of Oregon(Department of Physics), Universität Konstanz, NTNU Virtual Physics Laboratory and University of Cambridge.

Other than that, a costly virtual physics lab project using high technology and expertise is also created. Science Space labelled as the most ambitious project is produced from the collaboration between educators, sciencetists and computer specialists at George Mason University in Fairfax, Virginia, the University of Houston, and NASA's Johnson Space Center (also in Houston). ScienceSpace is at extreme high end of VR projects being used in US schools. Donning head-mounted color displays and haptic vests, students navigate through immersive environments that run on hefty CPUs and software created at NASA and grant money from the National Science Foundation [5].

Experimental Procedure

Based on the review conducted earlier, information gathering about hard to visualised physics concepts and experiments is done. Those concepts and experiments are based on Malaysia SPM syllabus.

A sample consisting of 11 schools (two of them being accredited `Smart School') around the northern area of Kedah were selected. The selection process was based upon the schools' academic achievement and performance. Topics ardous to students and whereby VR can help to achieve the above objectives were clearly indentified. The results is as shown in Figure 1.

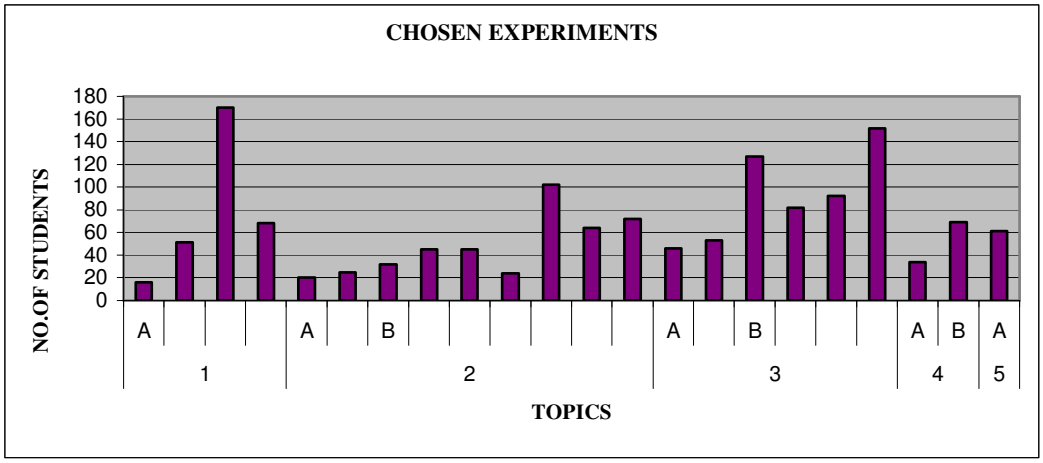

FIGURE 1: Hot topics for the Physics subject (refer to Appendix A for alphabets representation)

The selection of above topics for the respective subjects are based on two main factors i.e. the level of difficulties of the experiment and also their suitability to be virtually implemented.

An analysis has been done on the response obtained from teachers and students about the difficulties faced when explaining and understanding some particular concepts and experiments. This research is particularly referring to the one that cannot be explained in an actual environment caused by lack of lab equipments (cost), dangerous or harmful to the environments. Those topics are:

i. Force and motion
ii. Pressure in fluid
iii. Termionic radiation
iv. Radioactivity
v. Nuclear masses

In the above subtopic there are a variety of physics concepts and experiments. Specifically, five of them have been chosen to be implemented in the virtual environment. They are:

i. Brownian Movement
ii. Gravitional Acceleration
iii. Buoyancy Principle (Archimedes)
iv. Termionic Radiation
v. Electron Gun

To facilitate the prototype development process, storyboards are created to show step-by-step phase of the experiments.

The research is still in its implementation process and a virtual physics lab is expected as an output.

Development Tools

Virtual Reality is also used to describe non-immersive PC-based systems that simply incorporate 3D graphics on the screen [5].

One of the most comprehensive surveys to date has found that PC-based VR systems are most practical for US schools today. Christine Youngblut(1999), a researcher at the Arlington, Virginia-based Institute for Defense Analyses, has reviewed more than 60 VR educational efforts around the world. She explains that while many interesting experiments are under way, the PC-based VR systems have the best chance of widescale adoption. As she puts it, they offer "many of the positive benefits of more high-end VR applications with little or no additional costs involved for the schools [5] .

Instead of utilising conventional VR tools to develop the virtual labs prototype, this research utilises a 3D Game Engine. This technique is seen as a potential due to the fact that games were made to run on almost any entry level PC with very minimal system requirement. Mohd.Fairuz Shiratuddin *et al* (2000) has demonstrated that a 3D Game Engine is not only meant for developing good-looking games but also it can be used to create real-world VR application [6].

The existence of virtual labs utilising VR technology as a teaching tool is hoped to spark a new dimension in the methods of teaching sciences subjects. With the positive growth of low-cost high performance computer system, VR is expected to be the next step in the computer user-interface (UI) evolution and this will be one of the means to aid government's `Smart-School' project.

Conclusion

Education through VR is a means to create, experience, and share a computer-generated world as realistic or as fanciful as the user imagines. To understand how to help students master complex scientific concepts, examining the general nature of learning is vital. First, a prerequisite for learning is attention: student must focus on or be engaged in an experience in order for learning to occur. Second, meaningful representations are necessary to communicate information (Hewitt, 1991). Third, multiple mappings of information can enhance learning (Kozma, Chin, Russel, & Marx, 1997) [2].

This virtual teaching aids (Virtual Physics Lab) is non-other than an alternative of meaningful representations to communicate information and is one of the method of multiple mappings of information.

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