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**A Development of Virtual Laboratory
as a Tool for Form Four Chemistry
Subject**

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**A DEVELOPMENT OF VIRTUAL LABORATORY AS A TOOL
FOR FORM FOUR CHEMISTRY SUBJECT**

DECLARATION

I hereby declare that the work in this thesis is my own except for quotations and summaries, which have been duly acknowledged.

21 November 2005

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ABSTRACT

The use of chemistry is to apply the mathematical procedures to the chemical phenomena. One of the major problems in chemistry learning is those students do the calculation that leads to a narrow focus on skills. By using the virtual laboratory, it can help to simulate the chemical phenomena to real world, as scenario based learning. Thus, this project presents a prototype of virtual laboratory to offer experiment virtually through multimedia approach. By using the virtual laboratory, the common tools in lab will be replaced by virtual tools to allow the student do the experiment task step by step by using simulation software. The objectives of this project are to evaluate the effectiveness of virtual laboratory in the performance learning and to develop a virtual laboratory for Form Four Chemistry subject in Particle Theory of Matter part. This project is focus to the desktop virtual laboratory as a teaching tool, explored by keyboard and mouse, with 2D and 3D visualization. The methodology of this research is Development Life Cycle Model to complete the project. In order to evaluate the effectiveness, questionnaire based on content related will be given to two groups of students, incorporating a virtual laboratory group and a real lab experimental group to compare the learning performance of the two groups.

CHAPTER 1

INTRODUCTION

1.0 Background of the Research

Now days, Information Technology (IT) is very important to be used as a tools in various areas. One of the main areas that IT can be applied is in the educational area and educational environment. Many hypermedia teaching systems come out that available to help the students in learning process. Information in this system can be stored and displayed in an interesting way rather than book which students may be restless and bored to read. The information can be enriched by containing not just text, but also images, animations, sounds, databases, and virtual reality information.

With virtual reality technology, it can work for educators as a tool in assisting students to become immersed in a learning environment where they can participate in their own learning in a technology based environment. Virtual laboratory is an example of a commonly available virtual reality format. By using the virtual laboratory, students can conduct the virtual experiments that featuring many characteristics and constrains normally associate with real experiments.

1.1 Problem of Statement

Based on experience and researches, during the science lab session in secondary school, those students do not know exactly steps in experiment they need to do and how the result of that experiment relates to the theory concept they learned in class. Department of Chemistry, Carnegie Mellon University and Learning Research and Development Center, University of Pittsburgh experts support this idea. They found that by using the typical textbook learning, student just does the calculation, leads to a narrow focus on skills. Those who could perform the textbook procedure on exams had difficulty designing the experiment and need help from human tutor.

In traditional teaching method, the most commonly used visual mediums are textbooks and lectures, which 3D and dynamic are difficult to represent. The science subjects require higher level of visualization and interaction to observe the virtual world from various angle perspectives, which is impossible in 2D worlds (Avradinis, Vosinakis and Panayiotopoulos, 1998).

Moreover, some of experiments are impossible to be conducted in actual laboratories that can not be applied in real world, such as moving among molecules. In addition, some of them are dangerous or costly to conduct in an actual laboratory (Pantelidis, 1993).

According to Arlene Russell (1997), most chemists had a chemistry set as a kid, so when they entered the discipline, they were building on a knowledge base they already had. One of the problems in science is that, students come in without that kind of experience to build on.

Virtual laboratory allows students to rapidly do experiments and to see “inside” solutions. It represents interaction with the materials that involves mix of experimental design with realistic 2D or 3D visualization feedback.

1.2 Aim, Objectives and Scopes

1.2.1 Aim of the Project

To develop a prototype of virtual laboratory for Form Four chemistry subject.

1.2.2 Project Objectives

- i. To evaluate the effectiveness of virtual laboratory in learning performance.
- ii. To develop a prototype of virtual chemistry laboratory for Form Four chemistry subject, The Particle Theory of Matter.

1.2.3 Project Scopes

This project keeps its focus on the Particle Theory of Matter (*Teori Zarah Jirim*) experiment in Chapter Two Form Four’s Chemistry subject, through Particle Motion in Air and Liquid (*Gerakan Zarah Di Dalam Udara Dan Cecair*). For content consideration, information provided is in Malay language according to the Chemistry Form Four KBSM textbook.

In terms of virtual reality, this project focuses to the desktop virtual laboratory as a teaching tool, explored by keyboard and mouse, with 2D and 3D visualization.

1.3 Project Significance

The researcher conducted this study because it provides the significance for the

- i. Educational technology developers: as a guideline for developing virtual laboratory educational tool
- ii. Teachers: as a different learning styles for educational effectiveness.
- iii. Another researcher: to provide value information as reference to study and analyze, for their research.

1.4 Overview of the Report

This thesis report covers the requirement analysis process of developing a prototype of virtual laboratory for chemistry subject and explains in briefly the progress of the project. It is divided into six chapters which are the introduction, literature review, project approach and methodology, construction, result and finding, and conclusion.

Chapter 1 is to clearly specify the Project Definition, to gives a clear target at which to achieve. It is the preliminary stage and also as continual reference point against which can assess the project progress. This chapter described obviously the background of the research, problem statement, aim, objectives, scopes and significance of the project.

Chapter 2 describes obviously the definition of terminology related to the project, discussion and critically evaluating past and existing project from various sources that have been collected.

Chapter 3 illustrates plainly the approach and project model used for this project. Besides that, this chapter also explains the methods of data collection used to gain the assorted data.

Chapter 4 represents blue print of the system design. The process of designing the outline contents of the system based on the system requirements and user requirements were clearly defined. Then, the process of designing storyboard, interface and system's flow chart began.

Chapter 5 represents the development approach and techniques, the software and hardware requirements of the system

Chapter 6 contains the summary of this project outcomes and recommendations for further work to be carried out.

Chapter 7 represent about summary, conclusion, limitation of this project and recommendations for further work to be carried out.

CHAPTER 2

LITERATURE REVIEW

2.0 Introduction

For this chapter, it describes the definition of pertinent technical terminologies and different methodology or approach to solve the same problem

2.1 Definition of Pertinent Technical Terminologies

2.1.1 Multimedia

Multimedia combines audio and visual material to enhance communication and improve its presentation. The origin of multimedia lies in the arts and education where there is a current tradition of experimentation in how communication is conveyed. (Ambron and Hooper, 1988; Barrett, 1992).

2.1.2 Three-Dimensional (3D)

Three-Dimensional (3D) computing results in images that represent objects along x, y and z coordinates, whether represented on a flat screen or projected as in a hologram. While objects can be shown in perspective and often can rotate, providing views of all sides, it is the objects that move, while the viewer appears to remain stationary (Auld, 1996)

2.1.3 Computer Simulations

Computer simulations are computer-generated versions of real-world objects or processes like chemical molecules. They may be presented in 2-dimensional, text-driven formats, or increasingly 3-dimensional multimedia formats. Computer simulations can take many different forms ranging from computer renderings of 3-dimensional geometric shapes to highly interactive, computerized laboratory experiments. (National Center on Accessing the General Curriculum, 2003)

2.1.4 Learning Styles

Individuals typically have their own preferences in the way that they perceive, collect and process information. These methods are referred to as "Learning Styles". The Academic Skills Center at Western Michigan University (2001) offers the following breakdown of learning styles

- Print: Learns through reading.
- Aural: Learns by listening.
- Interactive: Discussions one-to-one basis or in small groups.
- Visual: Learns by looking at pictures, graphs, slides, demonstrations and films.
- Haptic: Learn through the sense of touch such as drag and drop interactions.
- Kinesthetic: Learns through movement, for example the animation.
- Olfactory: Uses the sense of smell in learning.

2.1.5 Virtual Reality (VR)

Virtual Reality (VR) is the simulation of a real or imagined environment that can be experienced visually in the three dimensions of width, height, and depth and that may provide an interactive experience visually in full real-time motion with sound and possibly with tactile and other forms of feedback. The main reason for using VR instead of physical is cost saving, reduce development time and improved quality (Ostman, 1998).

According to (Fernie and D.Richards, 2002), there are many common applications for VR. They fall into the main categories of education, training, simulation, visualization, conceptual navigation, design and entertainment.

2.1.6 The Types of VR

Generally, VR environment can be divided into two types, which are: (Zakirah Othman, 2002)

- i. The simulation of real environments (Such as the interior of a building or a spaceship often with the purpose of training or education)
- ii. The development of an imagined environment (Typically for a game or educational adventure).

The main types of VR system is divided into three types (Kalawsky, 1996)

i. Non-Immersive (Desktop VR) Systems

Desktop VR system is the least immersive implementation of VR techniques. Using the desktop system, the virtual environment is viewed through a portal or window by using a standard high resolution monitor. Interaction with the virtual environment can occur by keyboard, mouse and trackballs or may be enhanced by using 3D interaction devices.

ii. Semi-Immersive Projection Systems

A semi-immersive system will comprise of a relatively high performance graphics computing system which can be coupled with a large screen monitor, a large screen projector system or multiple television projection systems. Stereographic imaging can be achieved, using some type of shuttered glasses in synchronization with the graphics system.

iii. Fully Immersive Head-Mounted Display Systems

The most direct experience of virtual environments is provided by fully immersive VR systems. These systems are probably the most widely known VR implementation where the user either wears an HMD or uses some form of head-coupled display such as a Binocular Omni-Orientation Monitor or BOOM (Bolas, 1994).

For this project, it kept focus on the simulation of real environment in non-immersive (desktop VR) system as discussed in project scopes in chapter one.

2.1.7 VR in Educational Theory

Selwood (2000) claimed that research on VR suggests it has strong potential to be a powerful educational tool because it can exploit the intellectual, social, and emotional processes of learners.

Winn (1997) believed that three factors contribute to the capabilities and impact of VR which are immersion, interaction, and the ability to engage and motivate learners.

VR are relevant in three areas of educational theory, which are experiential education, constructivism and social learning. (Bricken and M.Byrne, 1991)

In many instructional settings, students acquire only facts rather than acquire tools for problem solving. They often have not experienced the kinds of problems that make information relevant and useful, so they do not understand the value of this information. (Bransford, 1990).

The experiential quality of VR provides a capability that is fundamental to the learning process (Dewey, 1996; Bruner, 1962; Papert, 1980). A virtual world is a place where participants can have any number of different learning processes. By including them within 3D multi sensory environments and coupling their natural behaviors to system functionality, participants feel a strong sense of presence (Zeltzer, 1990).

VR are constructivism environments in which participants can create, manipulate and edit any form of digital information. Children actively build their own categories of thought about the world (Piaget, 1929) and encouraging students to construct their own knowledge is demonstratively effective in learning (Jonassen, 1991; Spiro and Jehng, 1990).

Creating their own virtual worlds enables some students to master content and to project their understanding of what they have learned (Osberg and Winn, 1997).

In terms of social learning, VR provide capabilities for perceptual expansion, for creative development and for unique social interactivity (Bricken, 1991)

2.1.8 Generic Model of an Educational Virtual Environment

A good generic representation of a virtual design environment is given below, refer to Figure 2.1.

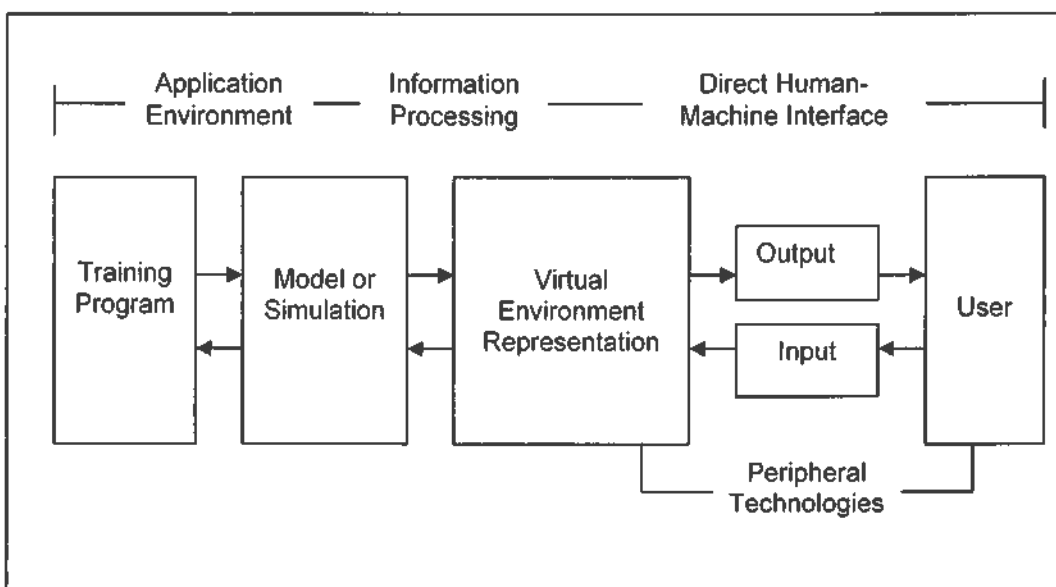


Figure 2.1: Generic Model of an Educational Virtual Environment

This simple representation of a virtual environment system identifies the closed loop nature of a VR System involving a user, input/output peripherals and a simulation environment. In order to provide an educational-perspective it is important to control the simulation by-a-training or education program. (Advanced VR Research Centre, 2000)

- Training Program

The training program represents a training module that takes advantage of the overall VR system. It is essentially an application program that is executed on the host computer and its purpose is to take the student through a carefully designed syllabus. This might take the form of conventional question/answer sessions or more likely, it will initiate responses according to the performance of the student. It will be important to ensure that the VR system is used for an appropriate task.

- Model or Simulation

The model or simulation is a mathematical representation of the system being used. It needs to take account of dynamic behavior in response to the student's input. Very sophisticated mathematical models can be written but it is the way that these are associated with an auditory and visual representation of the system. Students find it much easier to understand things from diagrams or models than simply looking at graphs or numerical output. The simulation can also make it possible to explore what if situations that would otherwise be impossible or dangerous to perform. This further improves the student's level of understanding. It would even be possible to let the student explore a system and make mistakes. In this way, the student will get the best possible understanding of the system operation.

- Peripheral technologies

Most people closely associate the peripheral technologies with VR since these represent the user's interface with the VR system. The peripheral technologies simply represent the input and output devices like mouse, head-mounted displays and glove.

However, the particular technology used is of critical importance and can mean the difference between a usable or useless system. Furthermore, the cost of the whole system is influenced greatly by the peripheral technologies. Since the user interacts with the VR system by means of the peripheral technologies, it is extremely important to ensure that these are matched to the perceptual needs of the user. An inappropriate interface may actually inhibit the learning process.

2.1.9 VR and Science Education

In terms of education process revolution, VR is impressive tool for science learning (Gay & Greschler, 1993). It bridges the gap between the concrete world of nature and the abstract world of concepts and models. The concretizing of objects – atoms, molecules, and bacteria, for example makes learning more straightforward and intuitive for many students and supports a constructivist approach to learning (Yair, Mintz & Litvak, 2001).

VR environments can make abstract concepts experiential to support student performance. “What VR does it is it takes things that are abstract and symbolic and it makes them sensory and experiential, interactive, so the kids can get a sense of why science works the way it does. And then link that back into the math, symbols and equations that are part of how scientists view what’s going on.” (Dr. Chris Dede, 1999).

Based on Fuhrmann and Greimel’s (2000) Teaching in Virtual Reality – Concepts and Evaluation research, natural sciences dominate the spectrum of applicable topics for teaching subjects in VR. They concluded, most of these are self-driven and naturally lend themselves to demonstrations and experiments, that suits with VR technology .Table 2.1 shows the result of their study.