

# **THE VIRTUAL CHEMISTRY LAB (VC-L): VIRTUAL REALITY AS A LEARNING TOOL FOR MALAYSIA'S SECONDARY SCHOOL**

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## **ABSTRACT**

Virtual Reality (VR) and its related technologies have paved the way to new opportunities that can be applied to improve current practices and processes in a variety of fields, including education.

This research paper presents the 'Virtual Chemistry Lab' (VC-L). The motivation for the research is the current challenges faced by students to learn and understand, and also by educators to teach chemistry using conventional and traditional means. The VC-L proposes a new method to assist current teaching practices. In supporting the VC-L proposal, issues such as cost, materials and time were among the elements studied and taken into consideration.

The steps engaged to accomplish the research objectives were: elementary research methodologies, preliminary studies that primarily concentrated on gathering information, prototype software application design and development, information analysis and documentation.

The WildTangent Web Driver and Autodesk 3D Studio MAX were the software development tools used to design and develop the prototype application.

**Key words: Chemistry, Education, Virtual Lab, Virtual Reality, Web-Based, WildTangent**

## 1.0 INTRODUCTION

Virtual Reality (VR), being the third era in the Human-Computer Interaction (HCI) exhibits a system that is able to create a virtual environment (VE) that exists entirely inside the computer. VR is able to display elements of 3-dimensional (3D) in terms of sight, hearing and the sense of touch (haptic) (Mandel, 1994). In many ways, VR has created a new window of opportunity towards assisting and improving educational processes and techniques. Youngblut (1998) states that the characteristics of VR support the theory of 'constructivism' that is able to create a 'learning-by-doing' atmosphere.

The advancement in computer technology has allowed further development of real-time 3D computer graphics, auditory and kinesthetic environments where students can be perceptually "immersed". According to Scardamalia et al. (1989), the optimal learning environments should be "active, learner-centred, engaging, relevant and robust." Hence the characteristics of a 3-D interactive environment have to be closely aligned with those of an optimal learning environment.

The characteristics of VR are relevant in the three main areas of 'Educational Theory' i.e., (a) experiential education, (b) constructivism and (c) social learning (Bricken, 1991). This research examined whether constructivist practices in the classroom or laboratory help students to make deeper, more meaningful knowledge constructions than those derived from traditional laboratory practices. This research therefore describes the relationship between the learning theory known as 'constructivism' being the semiotic theory of signs and the use of 3D interactive environments as a constructivist-learning tool (Osberg, 1997)

VR techniques will be a major influence upon educational processes in the future. The impact of these virtual teaching aids will depend upon the delivery of the teaching programme. A broad spectrum of technological concepts could be made available but it will be imperative to understand where, why and how to apply them (Kalawsky, 1999).

Pantelidis (1997) offers some ways to determine where VR can be most useful in the classroom. First, she says, VR should be used to teach subjects where standard lessons might be dangerous, harmful to the environment and costly. She also suggests, VR applications make sense in exposing students to learning environments that could not otherwise be experienced, such as visiting Mars, travelling inside the human body or moving around molecules (Seth, 1999)

This research paper presents the 'Virtual Chemistry Lab' (VC-L). The motivation for the research the current challenges faced by Malaysia's secondary students to learn and understand, and also by educators to teach chemistry using conventional

and traditional means. Loftin et al. (1999) and researchers at the Johnson Space Centre, as stated by Seth (1999), believe that a new approach in science education is needed. Furthermore, Loftin states that:

*“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.”*

The VC-L proposes a new method to assist current teaching practices. In supporting what was proposed by the VC-L research, issues such as cost, materials and time were among the elements studied and taken into consideration. One of the main features of the VC-L was the ability to display experiments that were difficult to be realised and seen by the naked eye in the physical world. It is hoped when VR is introduced to be a part of the Malaysian educational system, the outcome of this research will be invaluable in assisting the growth of the government's 'Smart School' project.

## **2.0 DISCUSSION**

With the current transition from the industrial age to the information and knowledge society, traditional instructional approaches based on the use of textbooks in classrooms have raised some questions. Instead of just memorising facts, more emphasis is now being placed on higher levels of thinking skills that are needed to construct and apply the knowledge. Students must learn to locate, interpret and creatively integrate information, to isolate, define and finally solve the problems.

Therefore education can no longer be confined in classrooms or to certain lengths of time in a person's life. Instead, education will be a life long quest and must meet the needs of a flexible workforce (Youngblut, 1998).

Some other researches indicate that students' posture and interest in science is seen to be declining as they move from primary to secondary and then higher education level.

One of the main problems in science education surface when students face abstractions. Suip (2000) believes that computer visualization tools are particularly effective to overcome this problem. Suip has proven that a student's attitude towards science subjects is influenced by surrounding variables. He describes in support of earlier researches that the interest of students in science can be increased through various methods and models of teaching. As such, this research utilised VR as the technological teaching tool. This research studies the effectiveness of

VR as an alternative means of educating. VR can assist the presently available teaching tools in diversifying methods of teaching. VR can also make experiments and hard-to-understand concepts, easy and interesting for both students and teachers to explore and learn.

Recent advancement in computer technology and 3D computer graphics has created new possibilities. Visualization of 3D objects and data has become increasingly important in learning scientific matter e.g., atomic and molecular science, fluid dynamics etc.. Using VR, the visualization of complex data and the building of more adequate conceptual models are possible (Shiratuddin *et al.*, 2000).

### **3.0 THE VIRTUAL CHEMISTRY LAB (VC-L)**

The VC-L will introduce a new dimension to the educational techniques of science subjects. Traditionally, students learn through assimilating all that is taught. Dede (1995) as quoted by Youngblut (1998) observe that, *“on the other hand, the ‘constructivism’ pedagogical philosophy states that it is much easier for students to master, remember and innovate new knowledge and ideas whenever they are actively participating in a ‘learning-by-doing’ situation”*.

The whole concept of utilising VR in Malaysia’s education system will help the development of the government’s Smart School project. In its plan for the Smart School, the Ministry of Education of Malaysia has outlined for the fiscal year of 2000, that 9 smart schools will be built and these schools will fall under the “A” category. Each of these schools will be equipped with 2 computer labs. All sciences labs will be provided with computers based on the ratio of 5 students to a computer (5:1) (Kementerian Pendidikan Malaysia, 1998).

### **3.1 Traditional And Smart Pedagogy**

Smart pedagogy has shown several new changes as compared to traditional pedagogy. Smart pedagogy utilises resources such as technology to explain and stimulate learning. The comparison between the two pedagogies is shown in Table 1.

**Table 1: Comparison between Traditional Pedagogy and Smart Pedagogy**  
 (Source:Projek Rintis Sekolah Bestari, <http://sedaka.net.tripod.com/b-menusrtsch.html>)

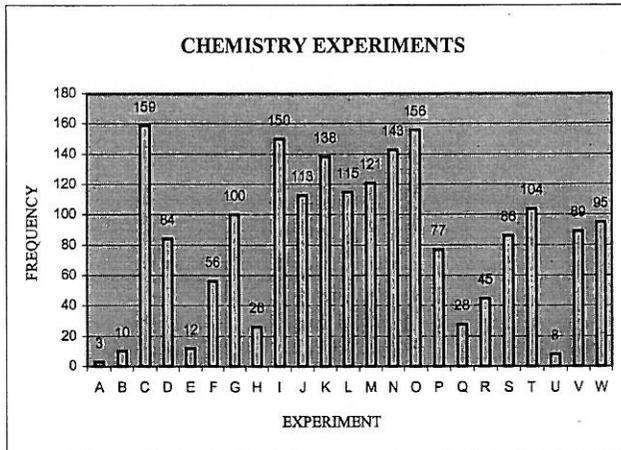
<b>Context</b>	<b>Traditional Pedagogy</b>	<b>Smart Pedagogy</b>
<b>Student</b>	Response based on teacher's instruction Easier assignment Individual effort	Response based on assignment More challenging assignment in terms of inquiry and provocativeness Cooperative in terms of participation and interaction
<b>Teacher</b>	Routine plan Stimulation limited to text Controlled environment Give answers more than questions	Creative plan Variation of stimulation Controlled environment Give questions more than answers
<b>Approach</b>	Teacher centralization Knowledge centralization Teaching centralization Product pointed Limited strategy	Student centralization Thinking centralization Learning centralization Process pointed Variation of strategy
<b>Classroom</b>	Fixed arrangement Desks and chairs arranged in rows	Flexible arrangement

	Activities limited in the classroom	Desks and chairs arranged based on activities and the need of the assignment  Activities are not limited in the classroom
<b>Curriculum</b>	Objective oriented  Knowledge based	Process oriented  Based on knowledge, skills and good values
<b>Resource  (Computer, OHP, Video, Television)</b>	Centralized  Strict borrowing procedure  Used as learning perimeters  Technology used to explain and to clearly express	Decentralized  Easy to get resource  Used as learning parameters  Technology used to clearly express and stimulate learning

### 3.2 Data Gathering

Through literature review, information on the difficulties of students to visualise chemistry concepts and experiments in Malaysia's SPM (Sijil Pelajaran Malaysia) syllabus was gathered.

In the data gathering phase, 11 schools were selected (two of them are accredited as 'Smart School') around the districts of Alor Setar and Kubang Pasu in Kedah. The selection was based upon the schools' academic achievement and performance. This stage surveyed and clearly identified the topics arduous to students and where VR can be used to achieve the research objectives. The survey involved both students and teachers. The hot topics identified are shown in Figure 1:



**Fig 1: Hot topics for the Chemistry subject**

The x-axis alphabetical representation is depicted in Appendix A (adapted from ICIMU 2001 – Romli et al., 2001)

Referring to Figure 1 and based on Form 4 and Form 5 Chemistry textbooks, 23 experiments have been selected. Analysis was done on the response obtained from students and teachers, on the issues of understanding and explaining some Chemistry concepts and experiments. This research mainly focused on topics that cannot be easily explained in the actual physical environment that may be due either to the lack of laboratory equipments, or to being dangerous or harmful to the environment and humans. In this research, five topics were chosen to be implemented in the VE. The selection is based on two main factors i.e., the levels of difficulty for students to understand the experiments and also their suitability to be virtually implemented. The topics were:

- Studying transition of matter
- Showing the electrolysis process for metal extraction
- Studying the redox reaction implicating the transfer of electrons at a certain distance
- Understanding the effect of action-reaction based on the theory of collision
- Understanding the process of soap cleansing

### 3.3 Experimental Procedure

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

The concepts and experiments that were virtually employed were based upon the levels of difficulty for students to understand and also their suitability. The levels of difficulty are based upon students' lack of understanding of the actual processes that by normal means cannot be practically shown or even visualized. For example to explain the concept of transition of matter in the molecular form, the process of soap cleansing and the effect of action-reaction based on the theory of collision etc..

Based on this result and without good visual assistance, it was clearly seen that Chemistry subjects were regarded as difficult to understand by many students. Therefore, a visualization tool was needed to aid student understanding. In some schools, it was discovered that some experiments could not be accomplished due to lack of suitable laboratory equipment that might be too expensive or considered hazardous. Examples were those related to redox reaction.

### 3.4 Development Tools and Prototypes

VR is also used to describe non-immersive PC-based systems that simply incorporated 3D graphics on the computer monitor screen (Seth, 1999).

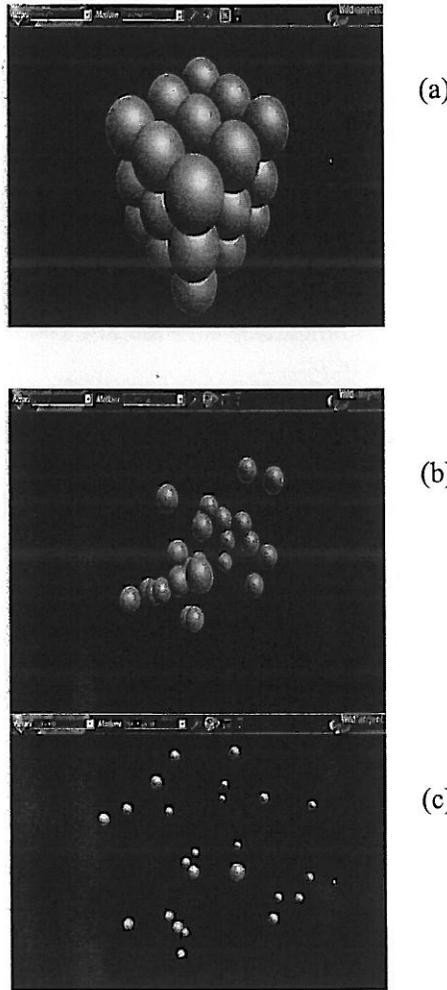
One of the most comprehensive surveys to date has found that PC-based VR systems are the most practical for US schools today. Youngblut (1998), a researcher at the Institute of Defence Analyses, in Arlington, Virginia, has reviewed more than 60 VR educational efforts around the world. She explains that while many interesting experiments are under way, the PC-based VR systems have the best chance of wide scale 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"* (Seth, 1999).

Based on this statement this research concentrated on using the non-immersive PC based system. Realising the need to use a low-cost high performance computer system, instead of utilising conventional VR tools to develop the prototype virtual lab, this research utilised a web-based 3D Engine known as WildTangent to create the VE. 3D modelling was done using Autodesk 3D Studio Max 3.1. This technique has big potential due to the nature of WildTangent itself that was primarily developed to run on most entry level PCs with minimal system requirement.

For non-commercial and educational purposes, WildTangent can be downloaded for free at <http://www.wildtangent.com>. WildTangent in general consists of two main parts i.e., the Web Driver which is the 3D Engine and also the 3D level editor called WTStudio. WTStudio was used to create the scenes and layout for this

research. Figure 3 shows some examples of the prototype experiments developed using WildTangent's software technology.

WildTangent software technology has the required and suitable tools that are needed to develop cutting edge interactive 3D media applications. Once developed, through WildTangent's powerful compression algorithm, the web-based applications can be efficiently delivered across the Internet.



**Fig 3: This figure describes the prototype experiment entitled: Studying the transitions of matter**

## **4.0 CONCLUSION**

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. The positive growth of low-cost high performance computer systems ensures that VR will be the next step in computer user-interface (UI) evolution. VR will also be one of the means to aid the Malaysian government's 'Smart-School' project (Romli *et al*, 2001).

Education through VR will be a means to create experience and share 3D computer-generated worlds as realistic and fanciful as the user can imagine. To understand how to assist students to master complex scientific concepts, examining the nature of learning is vital. Firstly, the prerequisite for learning is attention; students must focus on or be engaged upon an experience in order for learning to occur. Secondly, meaningful representations are necessary to communicate information (Hewitt, 1991). Finally, multiple mappings of information can enhance the learning process (Dede et al., 1999). The VC-L is an alternative of a meaningful representation to communicate information and is one of the methods for multiple mappings of information.

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