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The Virtual Lab (Physics & Chemistry) for Malaysia's Secondary School

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ABSTRACT

Virtual reality (VR) technology opens a vast opportunity to be applied in the field of education. This paper is based on a research that has been carried out upon the problems faced by students and teachers in the conventional science education. The "Virtual Physics Lab" and the "Virtual Chemistry Lab" propose a new method of assisting present teaching aids. The cost, materials, energy, and time issues are among the elements taken into consideration in this research. Elementary research methodologies, gathering information, prototype design and development and testing, information analysis and documentaries are the steps engaged to accomplishing the main research objectives. A 3D Game Engine is used as the tool to develop the prototype system.

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

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 that entirely exists inside the computer. VR manages to display elements of 3 dimensional in sight, hearing and the sense of touch (haptic) [4]. VR, in many ways has created a new window of opportunity towards assisting and also enhancing the educational processes and techniques. Also VR characteristics support the theory of *constructivism* hence able to create a 'learning-by-doing' atmosphere [9].

As quoted by [2] "computers are symbol-system manipulation tools (Kay, 1990; Duffy & Jonassen, 1992; Winn, 1995). Advances in computer technology have allowed for the development of real-time 3-D graphic, auditory and kinesthetic environments that students can be perceptually "immersed". In accordance to Scardamalia *et al* (1989), optimal learning environments should be "active, learner-centered, engaging, relevant and robust. Therefore, 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 areas of 'Educational Theory' i.e. (a) experiential education, (b) constructivism and (c) social learning (Bricken, 1991). The study examined whether constructivist practices in the classroom or lab help students to make deeper, more meaningful knowledge constructions than those derived from traditional lab practices. It, therefore describes the relationship between the learning theory known as 'constructivism', the semiotic theory of signs and the use of 3-D interactive environments as a constructivist-learning tool [2].

DISCUSSION

This paper is based on a research to tackle the challenges faced by Malaysia's secondary school 'conventional science' subjects teachers namely Physics and Chemistry. The 'Virtual Physics Lab' and 'Virtual Chemistry Lab' are developed and applied as an alternative to assisting present teaching processes and also to show off

experiments that are difficult to be realised in the physical world. Factors such as cost, materials, energy and time are some of the major elements taken into consideration for this research. It is foreseen when VR is introduced into the Malaysia's educational system, the outcome of this research will be one of the valuable resources to assist the growth of government's 'Smart School' project. Loftin (1999) and researchers at the Johnson Space Centre (1999) as stated by [6], believe that a new approach in science education is needed. Further, 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."

Other researches indicate that the students' posture and interest towards science is seen to be declining as they shift from primary to secondary and higher education level (Collete & Chiappetta, 1994; Head, 1985; Sharifah Maimunah Syed Zin & Lewin, 1993). It has been proven that a student's attitude towards sciences' subjects is influenced by their surrounding's variables (Anderson & Walbergh, 1968 and Gardner, 1976 for the Physics subject, Lawrenz, 1976 for the Chemistry subject) [8].

Shamsuddin Suip describes the findings by Woolnough (1993) to support earlier researches i.e. the interest of the students towards science can be increased through various methods and models of teaching. As such, this research utilises VR as the techno-teaching tool. This research studies the effectiveness of VR as an alternative teaching means to assisting the presently available teaching tools, to diversifying the methods of teaching and also making experiments and hard-to-understand concepts, easy and interesting to be learnt by both students and teachers [8].

Throughout the data gathering stage, 11 schools around the northern area of the districts of Alor Setar and Kubang Pasu, Kedah have been selected. The selection is based upon the schools' academic achievement and performance. This stage enables survey on topics arduous to students and whereby VR can help to achieve the above objectives. The survey involves both the students and the teachers. The results are as shown in Figure 1 and Figure 2.

Based on this result, it can be clearly seen that for the Physics subject, topics such as Kinematics and Dynamics, Material's Characteristics and Energy are regarded as difficult to understand by students without a good and clear visual assistance.

Experiments that cannot be accomplished in some of the schools are due to lack of suitable lab equipments that are expensive and considered hazardous if the experiments are to be conducted by the students themselves. Examples of the experiments are topics that relates to nuclear, termionics emission, electron guns etc.

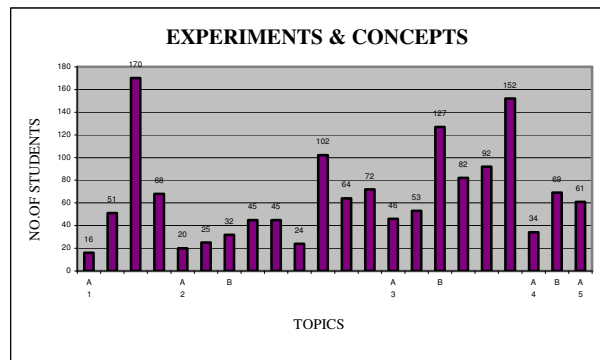


Figure 1: Hot topics for the Physics subject (refer to Appendix A for alphabets representation)

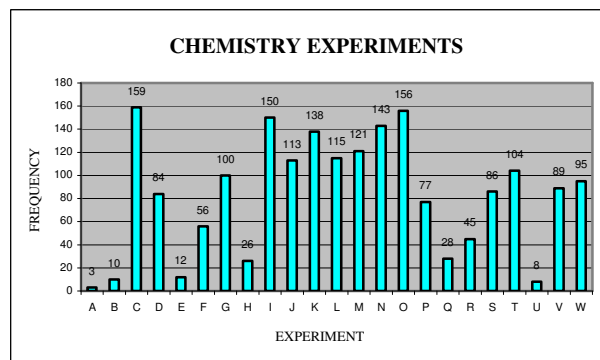


Figure 2: Hot topics for the Chemistry subject (refer to Appendix B for alphabets representation)

The concepts and experiments that are to be virtually constructed will be based upon the level of difficulties and also their suitability. The level of difficulties will be based upon the students' lack of understanding on the actual processes that cannot be practically shown or even visualised e.g. to explain the concept of 'Brown movement' for atoms, the 'Principles of Archimedes' and gravitational acceleration. Therefore, a visualisation tool is needed to aiding the students' understanding.

Referring to Figure 2 and based on the Form 4 and Form 5 Chemistry textbooks, a number of 23 experiments have been selected. Some of the experiments are (a) estimating the size of a single oil molecule (b) showing the electrolysis process for metal extraction (c) studying the 'redox' reaction implicating the transfer of electrons at a certain distance (d) understanding the effect of action-reaction based on the theory of collision (e) understanding the process of soap cleansing, etc.

The existence of virtual labs will spark a new dimension in the methods of teaching sciences subjects. In the traditional way of learning, students learn through assimilating all that is taught. Dede (1997) as quoted by Youngblut, *“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”* [9].

The expansion is estimated to help the development of smart schools when VR is introduced to the education system. The Ministry of Education of Malaysia in its plan for the Smart School has outlined for the year 2000 for 9 smart schools to be built and these schools will fall under “A” category. The A category school will be equipped with 2 computer labs while all sciences labs will be provided with computers according to the ratio of 1 computer to 5 students (1:5) [3].

TRADITIONAL AND SMART PEDAGOGY

The smart pedagogy has showed a few new changes as compared to the traditional pedagogy. A part from that, smart pedagogy had utilised resources as a technology to explain and stimulate learning. The characteristics of ‘Constructivism Theory’ had been fully applied. The comparison between the two pedagogies is as shown in the Table 1.

COMPARISON BETWEEN TRADITIONAL PEDAGOGY AND SMART PEDAGOGY

| Context | Traditional Pedagogical | Smart Pedagogical |
|----------------|---|---|
| Student | Response based on teacher’s instruction | Response based on assignment |
| | Easier assignment | More challenging assignment in terms of inquiry and provocative |
| | Individual effort | Cooperative in terms of participative and interactive) |

| | | |
|--|--|--|
| Teacher | Routine plan | Creative plan |
| | Stimulation limited to text | Variation of stimulation |
| | Controlled environment | Controlled environment |
| | Give answer more than question | Give question more than answer |
| Approaches | Teacher centralisation | Student centralisation |
| | Knowledge centralisation | Thinking centralisation |
| | Teaching centralisation | Learning centralisation |
| | Product pointed | Process pointed |
| | Limited strategy | Variation of strategy |
| Classroom | Fixed arrangement | Flexible arrangement |
| | Desks and chairs arranged in rows | Desks and chairs arranged based on activities and the need of assignment |
| | Activities limited in the classroom | Activities are not limited in the classroom |
| Curriculum | Objective oriented | Process oriented |
| | Knowledge based | Based on knowledge, skills and good values |
| Resource (Computer, OHP, Video, Television) | Centralised | Decentralised |
| | Strict borrowing procedure | Easy to get resource |
| | Used as learning perimeters | Used as learning parameters |
| | Technology used to explain and clearly expressed | Technology used to clearly expressed and stimulate learning |

Table 1: Source [5]

CONCLUSION

With positive growth of low-cost high performance computer system, VR is expected to be the next step in the computer user-interface (UI) evolution. This will be one of the means to aid government's 'Smart-School' project.

Realising the need to use low-cost high performance computer system, instead of utilising conventional VR tools to develop the prototype virtual labs; this research concentrates on utilising 3D Game Engines. This technique is seen as a potential due to the fact games are made to run on almost any entry level PC with very minimal system requirement. All computer games have engines and these engines are the backbone of the games [7]. Games that include 3D environment have 3D Game Engine behind them to take the description of 3D levels or virtual worlds. The main aim of 3D Game Engine is to generate photo-realistic images in real-time and display it on the computer monitor [1]. Furthermore, Mohd.Fairuz Shiratuddin has demonstrated that a 3D Game Engine not only can develop good-looking games but can also be used to create real-world VR application [7].

This research still ongoing and it will try to tackle problems that arise in the conventional methods of teaching science by using an alternative approach i.e. incorporating VR technology with the 3D game engine as a VR tool to develop the prototype of the 'Virtual Physics Lab' and 'Virtual Chemistry Lab'. Once the development is completed, the prototypes will be tested to the target groups and it is hope the result will be significant to aiding the Malaysian government's 'Smart-School' project.

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APPENDICES

Appendix A

Appendix B

Appendix A

ALPHABET REPRESENTATION FOR PHYSICS

1. KINEMATIK DAN DINAMIK

A. Dinamik

a. **Jisim dan inersia**

b. **Momentum dan keabadian momentum**

Prinsip keabadian momentum dan aplikasinya dalam perlanggaran
Perlanggaran kenyal dan tak kenyal

c. **Daya dan gerakan**

Paduan dan leraian daya
Keseimbangan daya
Daya dan kadar perubahan momentum
Daya tarikan graviti
Berat
Pecutan graviti
Impuls dan daya impuls
Prinsip perejangan
Enjin roket
Enjin jet

d. **Hukum kegravitian semesta**

2. SIFAT-SIFAT BAHAN

A. Kadaan jirim

a. **Pepejal, cecair dan gas**

Peresapan, pengembangan dan pemampatan
Perubahan keadaan jirim

b. **Teori kinetik jirim**

Pergerakan Brown
Peresapan udara

B. Sifat-sifat jirim

a. **Ketumpatan**

Hubungan antara ketumpatan dan susunan molekul

b. **Kekenyalan**

Hukum Hooke

c. **Kekuatan dan ketegaran**

Kekuatan
Ketegaran

d. **Tegangan permukaan**

e. **Tekanan dalam bendalir**

Tekanan dalam cecair
Tujah ke atas dan prinsip Archimedes
Pemindahan tekanan dalam cecair
Tekanan gas
Tekanan atmosfera

f. **Tekanan dalam bendalir bergerak**

Prinsip Bernoulli

g

Hukum-hukum gas

Hukum Boyle
Hukum Charles
Hukum tekanan
Hukum-hukum gas dan teori kinetik

3. TENAGA

A. Haba

a. **Pendidihan dan penyejatan**

Proses pendinginan dalam peti sejuk
Proses pendinginan dalam penyaman udara

b. **Enjin sebagai penukar tenaga**

Enjin empat-lejang

B. Atom dan tenaga nuklear

a. **Pancaran termion**

Senapang elektron

b. **Sinar-X**

c. **Keradioaktifan**

Eksperimen Elektroskop kerajang emas
Eksperimen Kebuk awan

d. **Tenaga nuklear**

Pembelahan nukleus
Tindakbalas berantai
Struktur dan prinsip kerja reaktor nuklear
Pelakuran nukleus

4. OPTIK DAN GELOMBANG

A. Optik

Eksperimen mengkaji penumpuan dan pencapahan cahaya oleh kanta nipis

B. Gelombang

Eksperimen mengkaji fenomena resonans dan ciri-ciri resonans
Eksperimen mengkaji fenomena pembiasan gelombang
Eksperimen mengkaji fenomena pembelauan gelombang
Eksperimen mengkaji pembiasan cahaya

5. KEELEKTROMAGNETAN

A. Keelektirikan

Eksperimen membuat pemerhatian untuk menunjukkan hubungan antara cas dengan arus
Eksperimen menunjukkan kewujudan medan elektrik

Appendix B

ALPHABET REPRESENTATION FOR CHEMISTRY

- (A) Mengkaji resapan gas bromin
- (B) Pergerakan zarah dalam cecair dan pepejal
- (C) Menganggarkan saiz satu zarah minyak
- (D) Mengkaji perubahan keadaan jirim
- (E) Mengkaji sifat kimia unsur-unsur Kumpulan 1
- (F) Mengkaji sifat kimia unsur-unsur Kumpulan VII
- (G) Mengkaji perubahan sifat oksida unsur-unsur Kala 3
- (H) Menentukan hasil elektrolisis leburan plumbum(II) Bromida
- (I) Mengkaji pengaruh faktor kedudukan ion dalam siri elektrokimia ke atas hasil elektrolisis larutan akues
- (J) Mengkaji faktor jenis elektrod ke atas hasil elektrolisis larutan akues
- (K) Menunjukkan pengekstrakan logam secara elektrolisis
- (L) Menunjukkan penghasilan arus elektrik daripada tindak balas kimia
- (M) Membina siri elektrokimia dengan cara mengukur voltan sel-sel ringkas
- (N) Mengkaji tindak balas pengoksidaan dan penurunan dari segi pemindahan elektron pada satu jarak
- (O) Mengkaji tindak balas redoks yang melibatkan pemindahan elektron pada satu jarak
- (P) Membina sel kimia ringkas dan mengkaji tindak balas redoks yang berlaku
- (Q) Mengkaji tindak balas redoks dalam proses elektrolisis larutan kalium hidrogen sulfat tepu
- (R) Mengkaji pengaratan besi dan kesan logam lain ke atas pengaratan besi
- (S) Teori pelanggaran (berkesan dan tidak berkesan)
- (T) Kesan kadar tindak balas berdasarkan teori pelanggaran (luas permukaan, kepekatan, tekanan, suhu & mangkin)
- (U) Lemak tepu dan Lemak tidak tepu
- (V) Pengumpulan lateks
- (W) Tindakan pembersihan oleh sabun dan keberkesanannya sebagai bahan pencuci