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## ABSTRACT

### AN INTERACTIVE 3-DIMENSIONAL WEB-BASED LEARNING TOOL: SIMULATING THE WITHDRAWAL REFLEX ARC CONCEPT

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Virtual Reality (VR) has demonstrated as a valuable medium for education and training purposes. Rather than presentation as such supplements the traditional classroom practices, VR facilitates learning through discovery.

An introductory 'Neurobiology' course primarily concentrating on the 'Reflex Arc' concept was simulated in a virtual environment and embedded on the Web page. The main objective of the research was to evaluate the students' comprehension rate of the simulated learning material. A group of 10 respondents whom were from the first, second and third year 'Cognitive Science' students of University Malaysia Sarawak - UNIMAS, were randomly selected to the experimental group (simulation session). A control group from the traditional lecture-hall session was also formed.

Research instruments used in this research were questionnaires and conceptual understanding test. The result exemplified a slight variation in the test outcome, with better result in the experimental group. The experimental group also showed their interest and gave full attention towards the simulated learning material as they were allowed to carry out a self-directed learning activity. The results supported the simulated learning tool as a potentially cost-effective approach to distributing courses over the Web.

*Keywords : Virtual Reality, World Wide Web, Conceptual Learning Simulation*

## ABSTRAK

### ALATAN PEMBELAJARAN INTERAKTIF-WEB 3-DIMENSI: SIMULASI KONSEP ARKA REFLEKS FLEKSOR

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Teknologi Realiti Maya (VR) telah berjaya dibuktikan sebagai satu perantara pembelajaran dan latihan. VR membantu pembelajaran melalui konsep penerokaan berbanding dengan kaedah penerimaan seperti yang kebiasaannya diamalkan dalam pembelajaran tradisional.

Suatu kursus pengenalan kepada subjek Neurobiologi, khususnya konsep 'Arka Refleks' telah disimulasikan di dalam persekitaran maya dan dipaparkan di dalam laman Web. Objektif utama projek ini ialah untuk menilai tahap kefahaman pelajar terhadap bahan pembelajaran yang telah disimulasikan. Untuk mencapai objektif ini, sekumpulan 10 responden yang terdiri daripada pelajar tahun satu, dua dan tiga kursus 'Sains Kognitif' Universiti Malaysia Sarawak – UNIMAS telah dipilih secara rawak. Mereka telah dibahagikan kepada kumpulan eksperimental iaitu untuk sesi simulasi dan kumpulan kawalan iaitu sesi kuliah tradisional.

Alatan kajian yang digunakan untuk ujikaji ini adalah soal-selidik dan ujian pemahaman konseptual. Keputusan kajian menunjukkan perbezaan minor dimana keputusan yang lebih baik ditunjukkan oleh kumpulan eksperimental. Kumpulan ekperimental ini juga telah menunjukkan minat dan memberikan tumpuan sepenuhnya terhadap bahan pembelajaran yang telah disimulasikan kerana mereka dibenarkan melakukan aktiviti pembelajaran sendiri. Keputusan menunjukkan simulasi alat pembelajaran ini sebagai satu pendekatan yang menjimatkan dalam menyebarkan kursus-kursus pembelajaran menerusi rangkaian Web.

Kata Kunci : Realiti Maya , World Wide Web, Simulasi Pembelajaran Konseptual

## **1.0 Introduction**

Interactive learning is not a novel pedagogical approach. The great philosopher, Socrates, has utilised this method in promoting active thinking among his students. Today, interactive learning particularly with virtual reality, involves considerably more than using a Socratic approach. It offers students unique experiences that are consistent with successful instructional strategies such as hands on learning, simulation and concept visualisation. The generation of good ideas and the understanding of certain concepts depend on mental images. With VR, mental images can be imposed on users and shared among them (Larijani, 1993). The three-dimensional (3D) nature of virtual environments can be used to great advantage to illustrate concepts not possible on a two dimensional (2D) page or in traditional classroom practices.

The realization and visualisation attributes of VR have made it suitable for simulating conceptual based information. VR allows information visualisation for supporting conceptual learning in medical education. Through 3D visualisation, students can understand important physiological principles or basic anatomy. Besides supporting conceptual visualisation, VR is also used as an interactive educational tool to support decision-making. The interactivity characteristic of the VR enables students to influence or manipulate the course of action not possible in real setting and allows conversant interdependency between user and system. As has been introduced by Socrates twenty five hundred years ago, interactive learning has proven its capability in simulating student's mind as well as promoting active thinking on their part (Barker, 1992). Today, this new technology has changed human relationship to information and is proving to be a valuable medium for education and training purposes. This approach facilitates learning through discovery rather than presentation and as such embodies all the benefits of experimental learning, whilst it can support and supplement more traditional classroom practices (Ramaiyer, 1998).

This paper describes the importance of web based Virtual Reality as a valuable medium to promote active thinking and experience for medical education purposes. The study examined whether the constructivism theory as supported by VR can help impart deeper knowledge construction in learning conceptual based information as compared to studying using conventional method (teacher centred). The conceptual based information simulated in this study covered the Neurobiology subject focusing on reflex arc concept. The simulation was developed on virtual environment software called Viscap 3D Webmaster. The 3D simulation of the subject materials was incorporated on the web to expand study opportunities for learners with Internet access.

## **2.0 Hypothesis**

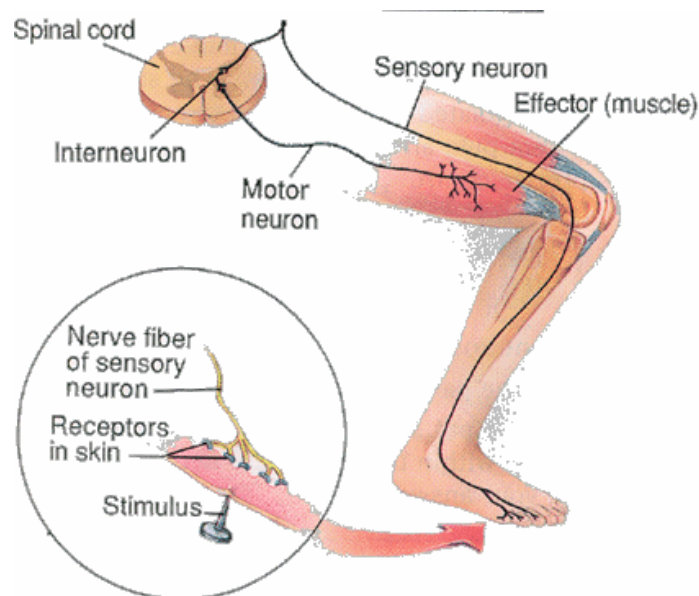
Neurobiology involves a great range of scientific endeavours (Riva, et al, 1998) describing electrophysiological events, tracking receptor binding and monitoring the physiological processes that take place in the nervous system. One of the key difficulties in neurobiology course is visualisation of the complex physiology concepts presented. The main obstacle in the building of intuition about the concept is the student's inability to visualise the items being learned. Many concepts have complex visual representations that cannot be sufficiently explored through the standard classroom experience (Begeman et. al., 1991). Thus, there is a need for graphical tools that will enhance the students' comprehension of these difficult concepts. It is hypothesis that VR can create an environment whereby complex concepts could be understood and the conceptual

interrelationships between objects be discovered by direct interaction and experience. VR is looked at as shared information context that offers unique interactivity and can be configured for individual learning and performance styles.

### 3.0 Application

A reflex arc includes five functional components: (i) receptor, (ii) sensory neuron, (iii) integrating centre, (iv) motor neuron and (v) effector (Tortora & Grabowski, 1993). It begins with a receptor at the end of a sensory neuron. A receptor is a specialised dendrite of a sensory neuron that has the ability to generate an action potential in response to a particular change in its environment. Once the receptor is stimulated by the sudden change, for example, a pain receptor stimulated by a prick at the end of a toe, the generated nerve impulse travels quickly along the sensory neuron to the spinal cord. Once inside the spinal cord, the impulse is transmitted to the association neurons, which make up the reflex centre that quickly processes the information by routing it to the appropriate motor neurons. The association neurons also have connections with other parts of the nervous system, explaining why one can feel pain from the prick and think about how best to treat it (after the emergency response is made) (Tortora & Grabowski, 1993; Solomon & Phillips 1987). The motor neurons then conduct the impulses to the effectors to bring about the response. The flexor reflex is *ipsilateral*, which means that the incoming and the outgoing impulses are on the same side of the spinal cord (Tortora & Grabowski, 1993).

As with other spinal reflexes, the withdrawal reflex arc starts with a sensory neuron and ends with a motor neuron. Figure 1.0 below shows chains of reflexes that form a reflex arc as a response to the tack pricking the skin surface of a toe. The impulse (represented by the arrows) travels from the toe to the spinal cord and back to the muscles in the foot, which jerks away from the tack.



**Figure 1.0: The Physiology of the Reflex Arc Process**

**Source: (Carola et al (1995))**

#### 4.0 Organisation of learning material

Understanding the concept of reflex arc mainly requires student to understand the process or the physiological function of the reflex arc system. Therefore the system was designed to construct student's understanding of the simulated concept. The way information presented in the virtual environment is both a didactic and experiential educational tool. The materials in the virtual environment were presented in two ways: *demonstration mode* and *step by step learning mode*. The *demonstration mode* consists of Lesson 1 and Lesson 2 whereas the *step by step learning mode* will be presented in Lesson 3.

##### *Lesson 1: Reflex Arc Action*

Give an introduction on the reflex arc action by simulating a condition where an avatar stepping on thumbtack and jerks his foot away from the stimulus.

##### *Lesson 2: Reflex Arc Process*

Demonstrate a tour of the functional component cycle of the reflex arc process starting from the stimulus until the effector muscle.

##### *Lesson 3: Step by Step Process*

Give a hands-on exploration by learning the components of withdrawal reflex arc physiological processes.

In strengthening learner's comprehension extent, the web page embedded to the virtual environment was fully utilised by creating a conceptual understanding evaluation section. The question-answering page was intended to test learner's comprehension over the concept that was simulated earlier on a 3D page. Apart from that, the web page also contains a Frequently Asked Question (FAQ) section and links to some related neuroscience web pages. Figure 1.0 below provides an overall structure of the learning material. Refer to Appendix A for snapshots of the 3D page.

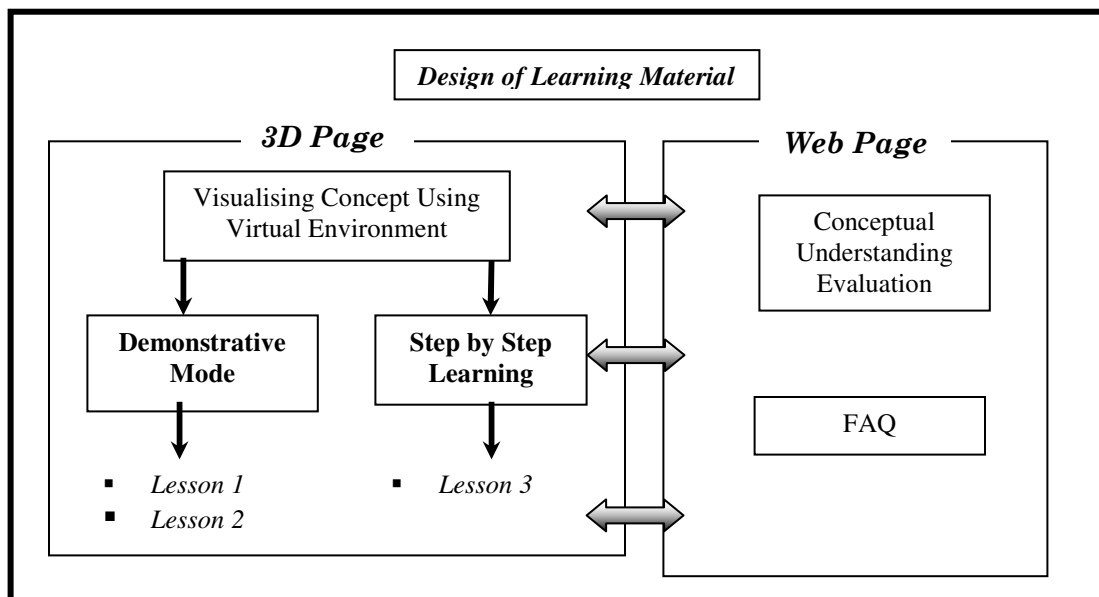


Figure 1.0: Overall Structure of the Learning Material

A short narration and guidance to provide a better understanding over the simulated concept has been created to accompany the scene. The demonstration mode for the reflex Arc Process lesson fully utilises the visual and hearing senses of learners because the explanation is jointly conducted with the movement of the view paths. According to Preece & Keller (1990), human being is estimated to receive relatively 95% of information either through visual or auditory senses. The use of visual representation alone especially in indicating a process is hard to accomplish since each process of the simulated concept requires some indication. The use of sound stimulus is able to attract learner's attention.

## **5.0 Methodology**

A total of ten respondents were involved in this study. They were divided into two groups. The first group was selected to learn the withdrawal reflex arc concept by using the web based 3D simulator. The second group was taught by using the traditional teaching method in which the interactions between the lecturer and students as well as the use of teaching aid in a 2D environment. The respondents for this evaluation study were randomly chosen from among the first, second, and third year UNIMAS Cognitive Science students, all of who have a common background in science stream, taking biology as one of the science subjects. This is to ensure that they would not be confused with a number of biological terms used in while conducting the experiments. Respondents who were asked to evaluate the system, which was currently developed, were ensured that they were capable of navigating the web page.

The research instruments used for the evaluation purposes were questionnaire and a conceptual understanding test. Measures of ten objective questions were prepared to evaluate the respondents' understanding of the concept being taught. The questionnaires were distributed in order to get feedback from the respondents on the suitability of the method in teaching subjects, which are conceptual in nature. The class for traditional learning was conducted in English so as to balance the information delivery and thus avoid biases in the students understanding of the subjects taught.

## **5.2 Observations**

From the evaluation result as well as observations made on the two respondent groups it was clearly shown that respondents who learn the concept from a 3D simulation gave full attention towards the subject taught. This is because they were given the freedom to carry out a self-directed learning activity, which allows them to obtain information on their own. They were given a controlling device (mouse) to navigate and interact with the learning tool. In addition, Viscap SVR allows them to reset the world interactively. On the other hand, learning provided by the traditional method offer the same kind of interactivity. Respondents learned interactively by asking questions to the lecturer. Nevertheless, respondents seem distracted during the learning process since they have to write down notes while listening to the lecture.

## **6.0 Results**

The results obtained from the two respondent groups showed slight variations. The first group, who were taught using a 3D simulation system showed better results as compared to the second group who were taught using the traditional method. Respondents in the simulation group yield higher score during the question understanding evaluation. Results

obtained from the questionnaire shows that respondents were able to navigate and understand the learning tool.

The respondents agreed that the conceptual understanding evaluation section in the web was suitable and agreed that it was very useful for strengthening student's comprehension on the simulated concept. The 3D objects in the virtual environment appear interesting and predominate their motivation to study the material. Contents of the learning material for the simulated concept are sufficient and agreed as informative. Presentation style seems comprehensible, apparent and interesting. Most of the respondents stated that they could replay or reset the 3D environment up to three to five times without causing boredom. The result also shows that the average number of times respondents have to replay the 3D environment was one to two times to really understand the content in the learning material. Despite the positive feedback procure in this research, the results also attest the disadvantages of learning using web based 3D simulation. The respondents agreed that the information displayed in the web based virtual environment couldn't be easily associated with other concepts in neurobiology if they do not have prior knowledge regarding the concept. The result also showed that it took quite a while for the 3D page to be loaded to the web page.

## **7.0 Discussion**

The research about the system was conducted to get feedback on the effectiveness of the learning material compared to the traditional learning. The system evaluation results showed that learner were more attracted toward the self-directed learning activity using the virtual environment learning tool. Although some disadvantages have been identified earlier, learners prefer to use the system compared to traditional learning since it provide high visualisation characteristics. Learning complex subject such as neuroscience requires students to be able to visualise the concept that are thought to them. Failure to visualise or understand certain concept will cause stress and lose of interest towards the subject. The traditional strategies used in the teaching of this subject tended to bore or otherwise intimidate students. Virtual reflex arc lesson would be appropriate for use either as adjuncts to or supplementary to the current practices in neuroscience education - a combination of lectures and concept visualisation.

Learning Withdrawal Reflect Arc concept via 3D simulation showed high visualisation ability among the respondents. Self-directed display and navigation that is allowed by the system make the respondents more interested to learn about the subject taught. This is clearly due to a change in the learning method, which is a shift from traditional to a new learning technique, which is more attractive and interesting. The outcome of the research supported our hypothesis that VR is able aid understanding of complex concepts and the conceptual interrelationships between objects discovered by direct interaction and experience.

Virtual environments can play an important role in reducing the cognitive demands on students by helping them to manage, filter and analyse multiple sources of information (Riva et al, 1998). Since VR technology accommodates non-linear storage and retrieval of information, this system can correspond more closely to human cognitive processes. As teaching aids, the VR may be enlisted to facilitate students' understanding at higher conceptual levels, encouraging students to questions and correlate ideas much more freely than is possible with paper-based, linear educational models (Larijani, 1993).



The influence of the World Wide Web (WWW) has grown exponentially and has become the medium for exchanging information. The integration of Internet and VR authoring tool into the desktop configuration have expanded the usage of VR in the classroom and added access to the networked world. Classroom uses of VR are limited, primarily due to the high cost of VR systems. Therefore the emergence of web based VR or 3D Page means that a solution to a particular problem can be utilised and shared with any user with Internet access. There are several reasons why this project is developed on a 3D page. The 3D page is a good place for interactive education purpose. The realisation and visualisation attributes of this new technology have made it suitable for simulating conceptual based information. It allows learners to explore and perform self-study and facilitates learning through discovery. Students also have the opportunity to explore plenty of new information since the web page can be linked to many additional sources. Nevertheless, publishing on the WWW provide ease of publishing, relatively low cost, requires low training needs ease in updating and distributing information and the potential in reaching a wide audience.

## **8.0 Conclusion**

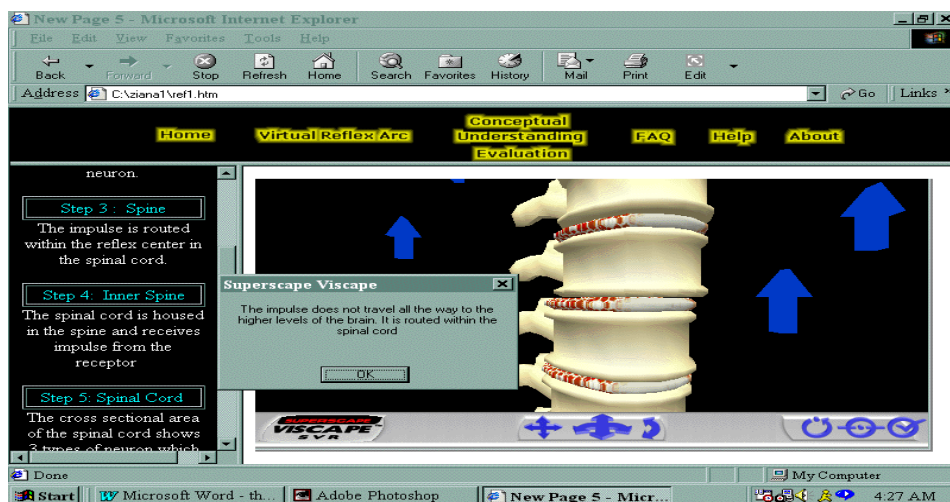
This system was built to serve as a learning tool for conceptual based learning. It is a learning tool that utilises the non-immersive virtual environment that simulates a concept by making it easy to visualise by the learner. Visualisation of the withdrawal reflex arc concept helps to show the interrelationship of the anatomy and the physiology that generates the action. This can help to reduce learner's cognitive strain in trying to visualise concepts that is hard to be viewed in real world. The ability of the learning tool may be able to open up a new dimension for learning complex concepts easily. VR gives the students a rare chance to initiate actions for themselves and to take control over aspects of their own learning. Empowering students to be responsible for their own learning can be supported by carefully designed virtual environment.

In the future, this project can be developed into an online courseware. Lectures can be made by representing the knowledge in the virtual environment and embedded onto the web page. The web page allows examination or quizzes to be put online. By expanding this project into a courseware may distribute information widely and help students who could not attend a physical campus.

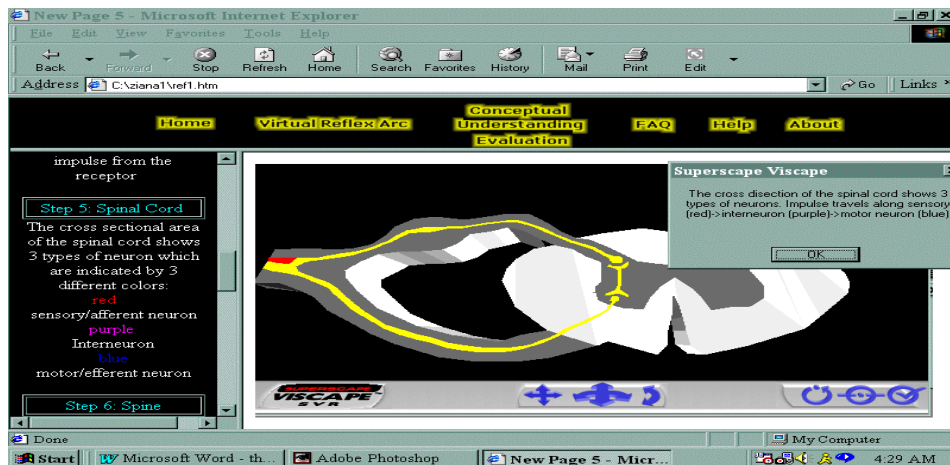
## Appendix A



A. *Simulation of an avatar action of what causes withdrawal reflex arc.*



B. *Simulation of impulse travel along the spinal cord.*



C. *Interaction of 3 types of neurones involves in conveying the impulse.*

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