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Virtual Laboratory for Learning Biology – A Preliminary Investigation

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Abstract**—**This study aims to conduct a preliminary investigation to determine the topic to be focused in developing Virtual Laboratory For Biology (VLab-Bio). Samples involved in answering the questionnaire are form five students (equivalent to A-Level) and biology teachers. Time and economical resources for the setting up and construction of scientific laboratories can be solved with the adaptation of virtual laboratories as an educational tool. Thus, it is hoped that the proposed virtual laboratory will help students to learn the abstract concepts in biology. Findings show that the difficult topic chosen is Cell Division and the learning objective to be focused in developing the virtual lab is "Describe the application of knowledge on mitosis in cloning".

Keywords**—**biology education, computer simulation, virtual laboratory, virtual reality

I. Introduction

MEANINGFUL learning occurs if students can relate their learning with their daily experiences. The aims of the biology curriculum for secondary school are to provide students with the knowledge and skills in science and technology and enable them to solve problems and make decisions in everyday life based on scientific attitudes and noble values [1]. By integrating science and technology in learning, they should still develop a concerned, dynamic and progressive society without omitting the preservation and conservation of the environment. The use of computers in promoting education is increasing. For example it can be used as information resources or as a platform for multimedia-based instruction. Apart from this, virtual reality (VR) technology such as virtual laboratory (VL) or virtual environment (VE) also reported many advantages over other learning techniques. As computers have become more prevalent in education, students' familiarity with the technology has enabled the development of more VR tools [2]. Thus, the innovations in developing a support tool for teaching and learning which is computer-related technology such as VL can offer an exciting opportunity to improve the quality of teaching and learning science subjects.

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II. Virtual Laboratory in Education

Practical experience is an important component in learning science subjects. Sometimes, there are few constraints such as time, safety and cost to set up the scientific laboratory in schools. However, these constraints can be resolved by using learning materials using computer-based technology which includes web sites, computer learning packages for tutorial and revision, virtual field trips, computer simulations and virtual laboratories. A solution to the above problem also can be found in the adaptation of virtual laboratories, which could be proven as an important educational tool that deals with the lack of practical experiences in education [3]. A VL is a virtual reality environment that simulates the real world for the purpose of discovery learning. It allows one, in principle, to evaluate real experiments and operations due to limitations of time, safety or cost in the real world environment and is usually used within science teaching [4]. VL is said to be equivalent in value to the learner because it addresses different learning styles and offers flexible and open ended environment for inquiry [5]. Even though a VL cannot be identical or equal to traditional laboratory or wet laboratory, it is worth to consider the weighing many benefits that it offers.

A. Benefits of Using VL in Education

There are many benefits of virtual laboratories, we consider the following as particularly important. With regard to time, virtual laboratories are considered convenient and flexible. By using virtual laboratory that relies on computer simulation rather than actual chemical and glassware, This will allow students to conduct the experiment safely even though they are studying at home, fun, students get hands-on chemistry experience without actually putting their hands on any dangerous chemicals and it also allows students to experiment on their own, instead of having to follow instructions rigidly, as they would in a traditional lab. Apart from that, in a new online microbiology lab offered by the University of Texas Medical Branch in Galveston, students don't have to worry about ruining bacterial cultures as they are part of a computer simulation [6].

III. Background of Study

Based on the benefits that virtual laboratories offer, study was done to investigate the status of biology teaching in secondary school. According to Integrated Curriculum for Secondary Schools for biology form four (equivalent to A-Level), the Biology curriculum aims at producing active learners. To this end, students are given ample opportunities to engage in scientific investigations through hands-on

activities and experimentations. However due to constraints to finish up the syllabus, cost and time for preparing the materials needed, sometimes the experimentations are not all done. Therefore, there is a need to try using technology such as computer simulation to overcome the problem since computer simulation and animation that can be presented through courseware or web page are effective tools for the teaching and learning of abstract or difficult science concepts [7]. Furthermore, the problem with the majority of the existing simulated laboratory developed so far is that the representation of the virtual environments and their components is very schematic and two dimensional [8]. Thus we hope that by developing a combination of two and three dimensional virtual laboratory for biology that referred to real laboratory environment in school could help to overcome the problem.

A. Related Work

Innovations in implementing the use of computer aided learning such as virtual laboratory offer an exciting opportunities to upgrade the quality of teaching and learning science. Research shows that the use of virtual laboratory in teaching science leads to improvement in learning the subject. Several interactive virtual laboratories are currently available on the web. The State University of New Jersey, Rutgers, has ten general biology lab exercises where seven topics are available to be used. The topics are cell structure, cell reproduction, protists, plant evolutions, angiopsperm reproduction, transport system in plants and chromosome structure and meiosis. A series of research were also done by researchers in developing and testing the use of virtual laboratory for learning which results in positive feedback. Virtual Laboratory Experiment (VLE) for biology which provide three dimensional (3D) graphic insights into the structures and functions of biological systems shown that students learn the principles of a biological system in a fast, effective and pleasurable way [9]. Eventhough programming virtual laboratories is a very tedious and costly task, it is proven that it can be used to augment real laboratory experience in science and technology. For example the virtual lab developed in collaboration with the University of Medicine and Dentistry of New Jersey which contains a set of objects such as microscopes, centrifuges, whole organisms, or individual cells each with specific pre-programmed behaviours verified that students interact with the objects in order to attain a set of given goals. The use of creative renderings of objects and their behaviours allow the student to freely experiment in the virtual world [10]. Using traditional method in teaching can be a challenge since students nowadays are visuo-spatially intelligent and talented [11]. Therefore, they may need to experience instruction that is visual and requires active participation. The virtual lab experience combines visual and auditory modalities and requires students to be actively involved [12]. Based on previous research done on using virtual laboratory in learning, many participants perceived the virtual labs useful to their learning experiences. With this in mind, we conduct a preliminary investigation to determine the topic to be developed for Virtual Laboratory For Biology (VLab-Bio). The following sections describe the preliminary investigation study.

IV. THE PRELIMINARY INVESTIGATION

A. Aim

The main aim of this study is to design and develop a VLab-Bio. Through this preliminary investigation, it is hoped to gather some data in order to determine the topic for the contents of the VLab-Bio.

B. Profile Of The Subjects

A group of 72 students from two secondary schools comprising of 38 girls and 34 boys. These participants were in form five (aged 16-17 years old) and had gone through the form four biology syllabus. Participants also involved ten biology teachers who were currently teaching biology in the selected schools.

C. Instruments

There were four instruments used in the study namely: Interview Schedule for Teacher (*Skedul Temubual Guru*-STBG), Biology Topic Difficulty Level Questionnaire for Students (*Soal Selidik Tahap Kesukaran Topik Biologi Pelajar* -SSTKBP), Biology Topic Difficulty Level Questionnaire for Teachers (*Soal Selidik Tahap Kesukaran Topik Biologi Guru* -SSTKBG) and Biology Question (*Soalan Biologi* -SB). The Reliability of the questionnaire instrument was done using Cronbach Alpha (α). Table I below shows the value of the α for the instrument.

TABLE I
THE VALUE OF CRONBACH ALPHA OF THE INSTRUMENT

Aspect	Teachers (α)	Students (α)
Level of difficulty for overall Instrument	.94	.97

D. Procedure

This study was done through a few steps in the preliminary analysis in order to determine the difficult topic thus will be included in the VLab-Bio. The steps taken is shown in Fig. 1 below.

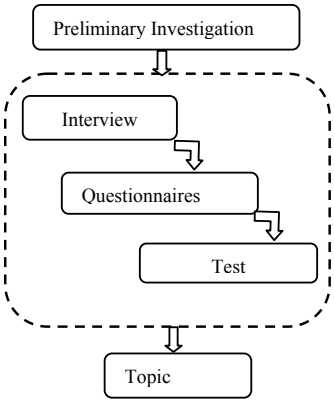

Fig 1: Steps taken in preliminary study

V. FINDINGS AND ANALYSIS

In this section we begin with findings of the interview using interview protocol form for teachers (*Skedul Temubual Guru*-STBG).

A. Findings of the Interview

The interview was conducted among 10 biology teachers in order to conclude whether there is a need to support the current teaching aids used in teaching biology. The result of the interview shows that teaching aids currently used by teachers are still restricted to powerpoint presentation and multimedia CD-Rom supplied by Curriculum Development Centre (CDC) and Educational Technology Division (ETD). Table II below lists out the teaching aids which are currently being used by teachers in teaching biology subject.

TABLE II LIST OF TEACHING AIDS USED IN BIOLOGY TEACHING

Item	Current Teaching aids used
Teaching Aids	• CD-Rom (supplied by CDC & ETD) • Model • Video from ETD • Power Point Presentation

Findings of the interview also reported several constraints faced by teachers when conducting experiment in biology laboratory. These constraints include insufficient supply of chemical solutions and malfunction of laboratory apparatus. Due to this, a laboratory assistant or technician need to be called and this consumed time. Apart from that, students are sometimes unfamiliar with the apparatus. This will obstruct teachers from getting attention from the students. By using computer based learning for laboratory experiments, time can be saved especially when the apparatus are found to be malfunction. It is reported that computer plays an important role in teaching and learning either in classroom or science laboratory. Thus, there is a need to develop a courseware for biology to help teachers and students in dealing with some of the problems they are facing when conducting an experiment.

B. Findings of the Questionnaire Survey

A survey using questionnaires SSTKBP and SSTKBG were distributed among students and teachers to know the difficult topic based on students and teachers perception. The questionnaire was based on a five-point (1-5) Likert scale whereby point 1 represents 'very easy', point 2 is 'less easy', point 3 is 'easy', point 4 is 'difficult' and point 5 is for 'very difficult'. The five points Likert scale was used to evaluate the difficulty level for each subtopic listed according to teachers' and students' perspective. Table III below shows the result of the questionnaires.

TABLE III AVERAGE MEAN (S.D) SCORED BY STUDENTS AND TEACHERS FOR EACH TOPICS IN BIOLOGY FORM FOUR SYLLABUS

Themes	Topics	Students mean (S.D)	Teachers mean (S.D)
1	Cell structure and cell organization	2.30 (0.83)	1.96 (0.48)
	Movement of substances across the plasma membrane	2.50 (0.82)	2.47 (0.51)
	Chemical composition of the cell	2.50 (0.84)	2.40 (0.51)
	Cell division	3.02 (0.79)	3.53 (0.64)
2	Nutrition	2.52 (0.94)	2.19 (0.63)
	Respiration	2.54 (0.93)	2.50 (0.63)
3	Dynamic ecosystem	2.59 (0.85)	2.27 (0.77)
	Endangered ecosystem	2.16 (0.95)	2.26 (0.65)

S.D. Standard Deviation

Table III, shows that topics are grouped under respective themes. The three themes are: Theme 1: Investigating the cell as a basic unit of living things, Theme 2: Investigating the physiology of living things and Theme 3: Investigating the relationship between living things and the environment. From the topic and subtopic listed it shows that Cell Division topic acquired the highest mean score from both teachers and students perceptions.

C. Findings Of The Test

In this preliminary investigation, we also conducted a test using SB based on Cell Division topic. A test paper contained of 15 multiple choice questions were distributed among 50 students. Fig. II below shows the percentage of correct answer for each question given.

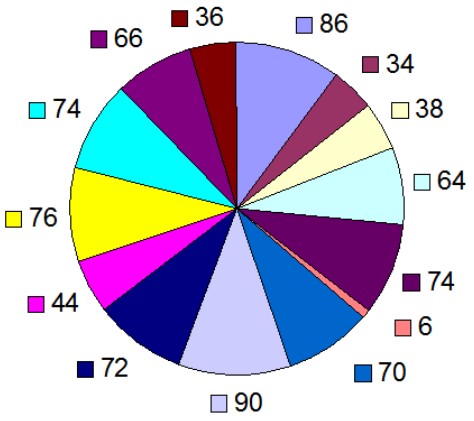

Fig. 2 Pie Chart shows the percentage (%) of corret answer for each question

In this investigation we concluded that the percentage of correct answer less that 40% is considered difficult by students. This investigation also shows that there were four questions that scored correct answer less that 40%. They are:

- Identify the phases in the cell cycle (34%)

- Explain the effects of uncontrolled mitosis in living things (38%)
- Describe the application of knowledge on mitosis in cloning (06%)
- Arrange the various stages of mitosis in the correct sequence (36%)

Based on this findings, we proposed to develop the virtual laboratory for biology where the focus of the learning objective is to describe the application of knowledge on mitosis in cloning.

VI. CONCLUSION & FUTURE WORKS

Findings of this preliminary investigation are supported by report released from Malaysian Examination Board (MEB) for Malaysian Certificate Examination (MCE) For Science and Mathematics Candidates. Findings also show that the difficult topic chosen by teachers and students is consistent with the mistakes that were found in the report. The steps taken in this preliminary investigation, contributed in identifying the suitable contents for learning biology via virtual laboratory. Thus, we hope that this virtual laboratory for biology can support students to explore and visualize the abstract concepts in learning biology especially in "Describing the application of knowledge on mitosis in cloning".

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