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Virtual Biology Laboratory (VLab-Bio): Scenario-based Learning Approach

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Abstract

The aspiration of the nation to become an industrialised society depends on various fundamentals in the fields of science and technology. The success in one's achievement can be planned ahead of time as to lead the nation into comprising of a plural society with global knowledge. In line with this, the Biology curriculum and syllabus are designed to create a scientifically and technologically oriented students and later, workers. Important components contained in science subjects like Physics, Chemistry and Biology include the aspects of doing experiment. As students embark in the process of doing experiment in the lab, they have to face some constraints such as safety, time and cost. Due to these obstacles, some topics in Biology in which experiments are part of, have not been done at school. Virtual technologies generally, and the Scenario-based Learning approach specifically, when integrated into a system in enhancing teaching and learning, have shown to be a promising tool to help students acquire knowledge in science. This study aims to i) identify teaching aids used by teachers in school, ii) investigate the topic that is to be focused in VLab-Bio and iii) analyse the examination reports to support the findings. This preliminary research uses the method of survey on 72 students and 10 biology teachers, interview and test to obtain data. Findings show that learning area under focus is Cell Division, the learning objective is Understanding Mitosis and the learning outcome is the Application of Knowledge on Mitosis in Cloning. Thus, this topic will be the main contents of designing learning modules intended to serve as a learning support tool of the Scenario-based Learning Approach for Virtual Biology Laboratory (VLab-Bio).

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1. Introduction

The potential use of information technology (IT) using computer -based learning has become popular and has gradually been adapted to many fields. The combination of IT and appropriate learning approach has shown a huge potential to be integrated in the education field. The use of this technology in teaching secondary level biology is enormous, although it is a huge undertaking and fairly daunting to newcomers (Peat & Fernandez, 2000). A Scenario-based learning approach puts the student in a situation or context and exposes them to issues, challenges and dilemmas and asks them to apply knowledge and practice skills relevant to the situation. Virtual technologies (VR) generally, and the Scenario-based learning approach specifically, when integrated into a system in enhancing teaching and learning, have shown to be a promising tool to help students acquire knowledge in science (Muhamad, Zaman, & Ahmad, 2011). Besides that, the advancements in technology such as simulation and virtual technology can also enhance the construction of analogies of natural phenomena through visual representations and realistic simulations based on the real phenomena (Sommer & Sommer, 2003). VR is one of the ranges of more recent computer-based technologies that may increase the possibilities for interactivity. VR has significant applications in the area of computing which takes the user into a synthetic environment. The VR environments are generally classified according to the types of technology employed to develop the VR environments ranging from 'fully immersive' in which the user is isolated from influences of the real world, to 'non-immersive' VR which is also called the desktop VR environment where the user is still aware of the outside visual world (Carnevale, 2003).

2. Virtual Laboratory in Teaching Biology

Conducting experiments in science laboratories can expose students to danger especially when it involves the use of chemical reagents or animal samples. Some accidents that might occur when conducting experiments in science laboratories are burns, electrical shocks, gas leaks, adverse chemical reactions and infections (Kurikulum, 1999). Hence, it is a good start to integrate the use of information and communication technologies (ICT) for teaching science subjects such as Physics, Chemistry and Biology, as these subjects involve a lot of practical work in the laboratory. Although hands-on activities in doing experiments are considered crucial that students for students to go through in order to accomplish the task given in the laboratory, using computers as learning materials including web sites, computer learning packages for tutorial and revision, virtual field trips and virtual laboratories (VL) also allow students to take part in the activities which are not available in the lab. VL is considered a new teaching strategy that is cheaper, easier and can attract students' attention in the learning process. It is reported that a few biology teachers use ICT in the laboratory work, which is recognized as a cornerstone of science teaching (Špernjak & Šorgo, 2010). Meanwhile many researches also proved that simple forms for representation learning material are not effective for teaching (Morozov, Tanakov, Gerasimov, Bystrov, & Acirco, 2009). On the other hand, scenarios used in virtual learning for teaching of Science have proven to be effective (Shanck, 1997). By integrating the use of scenarios based on specific themes in conducting science subjects' experiments, this can help students understand the topics learned in a more meaningful manner. This is due to the fact that they can relate real scenarios to the topics learned. Teaching strategies that mimic real situations through scenarios in a virtual laboratory environment through context, simulation, visuals and audio are expected to create more creative students (Bakar, 2010). Hence, a combination of the scenario-based learning approach and virtual laboratory simulations are effective tools in training students when involving the use of sophisticated as well as complicated instruments. In a scenario-based learning approach too, virtual field trips such as a trip to a tissue culture centre can also help students to develop ideas and skills on the subject matter before they visit the actual site.

2.1 Biology Curriculum Specifications

Meaningful learning occurs if students can relate their learning with their daily experiences. In Malaysia, the aims of the Biology Curriculum for secondary school are to provide students with knowledge and skills in science and technology and enable them to solve problems and make decision in their everyday life based on scientific attitudes and noble values (Ministry of Education, 2005). Generally, experiment is an important module in any science lessons. Conducting an experiment involves thinking skills, scientific skills, and manipulative skills where

students can test hypotheses through investigations to discover specific science concepts and principles. In schools, biology experiments are conducted in group because they involved high cost in terms of time, materials and chemicals especially when they need to be repeated. Besides that, certain experiments are also time consuming because preparations of apparatus, materials and chemicals need to be done earlier by the laboratory assistant. Although the importance of hands-on experiment in the science curriculum cannot be denied, advantages of computer simulations should also be taken into consideration. Using computer simulations like real laboratory eliminates the time required for equipment setup, reduces computation time, and increases the accuracy and reliability of results (Gandole, 2005).

2.2 Topic and Subtopics For the Scenario-based Approach for VLab-Bio

In order to set a focus topic to develop contents for the Scenario-based learning approach for Virtual Biology Laboratory (VLab-Bio) we will report some findings based on the preliminary analysis done earlier. A survey was done using a questionnaire to a group of 72 students from two secondary schools comprising of 38 girls and 34 boys. They were chosen because they had gone through the Form Four Biology Syllabus throughout the academic year. The survey also involved 10 Biology teachers. Participants were asked to choose the state and level of difficulty for each topic in The Biology Syllabus based on their experiences in learning and teaching the subject. The instrument used was a questionnaire which comprises of all themes, topics and subtopics in the syllabus. It was based on a five-point (1-5) Likert scale whereby point 1 represents 'very easy', point 2 'less easy', point 3 'easy', point 4 is 'difficult' and point 5 indicates 'very difficult'. Based on the result, we have made a conclusion that the topic which scores the average mean of more than 3.0 is considered difficult by students and teachers. Table 1 below shows the average mean score (standard deviation) scores based on the questionnaire.

Table 1. Average Mean (S.D) Based On Students' And Teachers' Perspective For Each Subtopic In Form Four Biology Syllabus

| Themes and topics | Students mean (S.D) | Teachers mean (S.D) |
|--|---------------------|---------------------|
| Theme 1: Investigating the cell as a basic unit of living things | | |
| 1. Cell structure and cell organization | 2.30 (0.83) | 1.96 (0.48) |
| 2. Movement of substances across the plasma membrane | 2.50 (0.82) | 2.47 (0.51) |
| 3. Chemical composition of the cell | 2.50 (0.84) | 2.40 (0.51) |
| 4. Cell division | 3.02 (0.79) | 3.53(0.64) |
| Theme 2 : Investigating the physiology of living things | | |
| 1. Nutrition | 2.52 (0.94) | 2.19 (0.63) |
| 2. Respiration | 2.54 (0.93) | 2.50 (0.63) |
| Theme 3 : Investigating the relationship between living things and the environment | | |
| 1.Dynamic ecosystem | 2.59 (0.85) | 2.27 (0.77) |
| 2.Endangered ecosystem | 2.16 (0.95) | 2.26 (0.65) |

S.D.: Standard Deviation

Based on this findings, the topic chosen for the Scenario-based Learning Approach for VLab-Bio is Cell Division. To set the contents of the learning objectives for VLab-Bio we have asked students to answer some multiple-choice questions (MCQ) on the topic. There were 15 multiple choice questions to test on various learning objectives for the topic of Cell Division. There are four learning objectives that scored less than 50 % correct answer from students. For the purpose of this study, we will consider the use of learning objectives which have scored less than 50% correct answer as the main contents for the Scenario-based Learning Approach for VLab-Bio. Detailed results of the test are given in Table 2, where four learning objectives have scored less than 50% correct answers from the students.

Table 2. Summary of results from the multiple choice test marks

| No | Learning Objectives | Percentage of Correct Answer (%) |
|----|---|----------------------------------|
| 1 | Identify the phases in the cell cycle | 34.0 |
| 2 | Explain the effects of uncontrolled mitosis in living things | 38.0 |
| 3 | Describe the application of knowledge on mitosis in cloning | 06.0 |
| 4 | Arrange the various stages of mitosis in the correct sequence | 36.0 |

From the table above, it can be seen that the learning objectives used to describe the application of knowledge on mitosis in cloning have scored the lowest percentage thus this objective will be our main consideration for the VLab-Bio contents.

Some additional results from the interviews also show that teaching aids currently used by teachers are still restricted to the PowerPoint presentation and multimedia CD-Rom supplied by the Curriculum Development Centre (CDC) and Educational Technology Division (ETD). There are also a few constraints faced by teachers when dealing with conducting experiments in their teaching of the subject. These constraints include insufficient supply of chemical solutions and the malfunction of laboratory apparatus. Due to this, a laboratory assistant or technician needs to be called and this consumes time. Apart from that, students are sometimes unfamiliar with the apparatus. This will make it difficult for the teachers to be paid attention by the students. In teaching Cell Division, students cannot see the process of mitosis because it involves some abstract concepts. The concept of traditional real laboratories in technical institutions including schools has many limitations. The experiment of animal cloning and tissue culture, as instances are never done in schools because they take a long time and also that they are costly. The availability of resources may also be too limited to provide basic as well as advanced laboratory equipments like those supplied in technical institutions. Even if the facilities are readily available, in many cases a student may end up being a spectator in the conduct of experiments, due to the fact that he or she is in a large group. Students are not free to do experiments according to their own schedules, as the time slot for an experiment may be limited to the usual working hours (Tiwari & Singh, 2011). By using computer-based learning for laboratory experiments, time can be saved especially when the apparatus is found to be malfunctioning.

Thus, there is a need to develop a learning support tool which we call A Scenario-based Learning Approach Virtual Laboratory for biology (VLab-Bio) to help teachers and students in dealing with some of the problems they are facing when conducting experiments in the Lab. The VLab-Bio consists of real situations or scenarios based on themes integrated with interactive activities, exercises and step-by-step information on the application of knowledge on mitosis in cloning. This VLab-Bio can complement the current teaching aids that are being used for teaching Biology. The VLab-Bio is aimed to help students simulate and visualize the process in acquiring knowledge on mitosis in cloning. Using the scenario-based learning approach in virtual laboratory, it would simulate students to conduct real experiments and operations instead of in the real lab environment, due to the limitation of time, safety or cost (Mahdavi, Metzger, & Zimmermann, 2002).

3. Learning modules in VLab-Bio

VLab-Bio is designed as a support tool to learn Biology. The addition of information and learning modules into the VLab-Bio is one of the challenging tasks. Effective learning components should be embedded by various means, not only about the experiments but also related theories and stories. Some of the means by which this may be done include:

- (i) Photographs and figures of machines and different apparatus provided in the VLabExplore module, so that users will know the apparatus and descriptions used in the process of tissue culture and animal cloning.
- (ii) Audio and video are also added in the VLab-Bio programmes. These demonstrate the narrator in the scenario episodes, experimental procedure and instructions that students have to follow.
- (iii) User manuals are provided before starting the experiment. The manual is designed as a guide for users to explore the VLab-Bio.
- (iv) Learners have to search through the laboratory to find the active icons, to go through steps of the tissue culture process. They are asked to watch two episodes of the short story scenarios that relate to the purpose of learning about tissue culture process.



Fig.1 Examples of the Animal Cloning module and Plant Tissue Culture in VLab-Bio



Fig. 2 Screenshots of episodes in the scenarios

As a learning support tool, VLab-Bio provides learners with a virtual learning environment with real graphics and photos to help them see the real apparatus and chemical used in the process of doing tissue culture and animal cloning experiment. Based on the episodes in the scenario, students can make an association of the problem faced in the situation with the objectives of their learning in the VLab-Bio.

4. Themes of Scenarios

Biology is generally a visual subject and concepts and examples are frequently presented as photographs and videos (Evans, J.Gibbons, Shah, & Griffin, 2004). There are two episodes of scenarios in VLab-Bio where students can visualize photographs and videos based on real problem- based experiences. An episode is a fact wrapped in an emotion that can compel us to take action and so transform the world around us (Chuah, Chen, & Teh, 2009). Scenarios in VLab-Bio are based on themes that relate to the purpose of the students in learning the topic chosen. We have adapted the themes of scenarios based on real problems which exist in related situations. The theme for scenario 1-Animal Cloning is based on experiences of a rabbit farm owner. The theme for scenario 2-Tissue Culture Episode is looking at a group of entrepreneurs who attended a tissue culture course in the Malaysian Agricultural Research and Development Institute (MARDI). Both episodes have a similarity, where the theme of the scenario is about disease attack on animals and plants that prevent a production of quality products. In Human Computer Interaction, scenarios are concerned with stories about people and their activities (Carroll & Rosson, 1991). Based on this, we create a video clip of each story using voices and photographs based on the suggestion compiled from the subject matter experts. An example of the episode is : “A rabbit farm is the location. Virus infection and loss is the theme. The farm owner and rabbits are objects that play a part in the episode”. For the purpose of this paper we shall only describe the short story episode for Scenario 1-Animal Cloning in the box below.

Mr Vijay is an animal lover. He has decided to turn his hobby into a successful business venture, raring rabbits. Everything went well. The breeding that he had done in place continued to be successful. Then, he started noticing that the rabbits were less active and unresponsive. To make matter worse, the skin started to get infected with open sores. One by one, his rabbits started to die. Exasperated with the situation, he consulted a veterinary at the animal clinic to seek for the solution.

Scenario 1-Short Story Episode For Animal Cloning

5. Discussion

Teaching and learning in Biology can be enhanced by the addition of appropriate laboratory component. However, for most topics, laboratory exercises are proven to be too expensive, time consuming or lengthy to adequately allow students to reinforce abstract contents and concepts taught in the classroom. The proposed Scenario-based learning approach VLab-Bio is expected to help in enhancing the learning and teaching of Biology, generally on the topic of Cell Division and specifically towards understanding the application of mitosis in cloning (animal cloning process and tissue culture technique). It is meant to provide an alternative to a traditional laboratory module. Modules developed in VLab-Bio would help to provide a particular advantage over conventional teaching and learning technologies due to the constraints in doing experiments in the conventional laboratory reported in the earlier research. The scenario-based learning activities in the virtual environment can create potential for increasing the standard of safety and reducing time and training cost in conducting experiments. It is reported that the cost of running laboratory works, along with safety considerations for particular reagents or protocol often dictates the experiment that students can perform (Breakey, Levin, Miller, & Kathryn, 2008). By using the Scenario-based learning approach VLab-Bio, students' performance of tasks in a realistic simulation of the environment can well illustrates the exposure to the experiments that have not been done at schools due constraints mentioned earlier. It also provides opportunities to see how the classroom knowledge is applied in the context. This approach also anticipates that the students would sharpen their skills and better their understanding by practising the step-by-step process of animal cloning and tissue culture based on real scenarios.

6. Conclusion

The Scenario-based learning approach VLab-Bio is intended as a teaching and learning support tool for Form Four Biology. Based on two episodes of short stories that relates to the real problem faced in everyday life, students will be able to know the purpose for studying the topic chosen. Students can actively participate in the experiments and proceed with the decision that they are required to make. Providing a Scenario-based learning approach VLab-Bio is also considered to be a very helpful tool for both teachers and students who previously have limited opportunities or time to conduct experiments in the biology labs. The ability to instantly see the result of an experiment is an advantage over the conventional laboratory practice, which can extend over several days, and can allow students to not worrying too much if they happen to forget the experimental details or lose interest in the results of a particular experiment. Therefore, we have included the episodes of related stories to be analysed in the Scenario-based Learning Approach of Virtual Biology Laboratory (VLab-Bio) learning support tool.

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