Research Paper Education

Enhancing Biological Sciences Laboratory Experimental Skills Through Virtual Laboratory Techniques

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ABSTRACT

Appropriate practical work enhances pupils experience, understanding, skills and enjoyment of science. Practical work enables the students to think and act in a scientific manner. The scientific method is developed with the infusion of laboratory experiments interrelated with theory. Nowadays, due to the unavailability of real objects for biology practical, one should really depend on technological mediated laboratory skills in learning biology practical skills. Multimedia based Virtual laboratory replaces the real objects in the biology laboratory and it helps the student and teachers to enhance the laboratory skills in the area of biology learning.

Keywords : Biology laboratory skills, Virtual laboratory Techniques, Science process skills, Biology Hands on Experience Strategies.

Introduction

A good science curriculum must not only give balanced emphasis to both theory and experiments but also integrate two essential and complementary aspects of science in the teaching learning process. Modern science, as we all know, is the interplay of experiments, observations and theoretical inference. Laboratory practices generally aim to improve the students' abilities by providing observation and utilization of equipments for conducting the experiments. The laboratory is an indispensable aspect of science teaching because the laboratory provides students with opportunities to engage in the processes of investigation and inquiry. It provides students with some understanding of the nature of biological sciences.

The establishment of regular laboratory instruction in science teaching was credited to Liebeg (1803 - 1873) who made laboratory work available for postgraduate study in science. By the nineteenth century the study of science had become popular worldwide and laboratory instruction was introduced in different parts of the world. According to Ausubel (1968), the laboratory "gives the students appreciation of the spirit and method of science, it promotes problem-solving, analytic and generalization ability. Nzewi maintained that practical activities should engage the students in hands-on, mind-on activities, using varieties of instructional materials/equipment to drive the lesson home. Nwagbo (2008: 41) stated that: The use of practical activities (approach) to the teaching of biological concepts should therefore be a rule rather than an option to biology teachers, if we hope to produce students that would be able to acquire the necessary knowledge, skills and competence needed to meet the scientific and technological demands of the nation.

NEED FOR PRACTICALS IN BIOLOGY COURSE

Student laboratory activities should be designed to develop 'higher' cognitive skills that underpin scientific methods of working (Woolnough, 1991). However, research studies have shown that the most practical tasks in science laboratory manuals are prescriptive, providing little or no opportunities for open-ended or enquiry-based learning and that practical work can be unproductive and little learning of science goes on with students in practical classes.

Effective biological science practical work, need to consider the following:

- Students must be provided with opportunities to manipulate equipment and materials while working cooperatively with others in an environment in which they construct their scientific knowledge and engage in processes of investigation and enquiry (Tobin, 1990).
- The intended learning outcomes of doing the practical work must be made clear in students' minds so that students will not be confused with the complexity of the practical task while carrying it out (Millar, 2004).
- The practical tasks are well-designed and focus on certain and in depth topics to help students acquire and develop science concepts or frameworks of concepts (Hofstein and Lunneta, 2002).
- In order for learning to occur with practical work, students need to be given sufficient time to interact, reflect and discuss (Gunstone and Champagne, 1990).
- Students be taught how to take control of their own learning and provide opportunities for metacognitive activities, rather than concentrating on technical ones (Gunstone 1991).

Teaching strategies in Developing Experimental Skills in Biology

Learning in biological science is a combination of understanding, conceptualisation and practical experience. Visualisation and conduct of laboratory experiments are the most effective ways to simplify and clarify the comprehension of complex theory. However, there are inconveniences with these traditional educational methods due to the constraints of geography, time schedule, supervision, materials and cost. More over nowadays more constraints are developed in using rare living beings for practical purposes in biology. Environmental threats have been forced certain objects, which have not been available in the natural settings. In addition for developing any types of experimental skills require rigorous practice and repetition. So in due course of such events the living organisms slowly destroyed from our mother earth. For minimizing such happenings in our earth we should practice virtual laboratory techniques to enhance experimental skills in biology practi-

cal. Computer-based virtual learning environments open new realms in the teaching, learning and practice of the Life Sciences. Virtual learning environments provide students with the opportunity to achieve learning goals, without constraints. VLE-based applications have thus emerged in mainstream education in schools and universities as successful tools to supplement traditional teaching method Virtual learning environments provide three-dimensional (3D) graphic insights into the structures and functions of biological systems. Students can thereby learn the principles of a biological system in a fast, effective and pleasurable way by interacting with and navigating through the VLEs (Amon, 1999).

Developing Biology Laboratory skills through the Virtual laboratory Techniques

Computer simulations give students the opportunity to observe a real world experience and interact with it. In science classrooms, simulation can play an important role in creating virtual experiments and inquiry. Problem based simulations allow students to monitor experiments, test the new models and improve their intuitive understanding of complex phenomena (Alessi and Trollip, 1985). Simulations are useful for simulating labs that are impractical, expensive, impossible, or too dangerous to run (Strauss and Kinzie, 1994). Computer simulations take many different forms from 2 or 3-dimensional simple shapes to highly interactive, laboratory experiments and inquiry environments. "A simulation is a powerful technique that teaches about some aspect of the world by imitating or replicating it. Students are not only motivated by simulations, but learn by interacting with them in a manner similar to the way that they would react in real situations. In almost every instance, a simulation also simplifies reality by omitting or changing details. In this simplified world, the student solves problems, learns procedures, comes to understand the characteristics of phenomena and how to control them, or learns what actions to take in different situations."

Science Process Skills

Simulations can activate science process skills of students, which are the basic skills for scientific inquiry. These skills are classified in two main groups: basic science process skills and integrated science process skills. Padilla (1990) listed basic science process skills as observing, inferring, measuring, communicating, classifying, and predicting. He listed integrated science process skills as controlling variables, defining operationally, formulating hypotheses, interpreting data, experimenting, and formulating models. Lazarowitz and Huppert (1993) examined computer simulations in promoting science process skills of 10th grade biology. Their findings indicated that computer simulation can enable students to use the skills of graph communication, interpreting data, and controlling variables in simulated experiments, and helped them master these skills.

Mintz (1993) examined computer simulations as an inquiry tool. Inquiry is fundamental for science learning (National Science Education Standards, 1996). Inquiry procedure included positing hypotheses, conducting experiments, observing and recording data, drawing conclusions. They concluded that computer simulation can expand and improve classroom work. According to their findings, simulations as an inquiry tool improve motivation and interest. However a Hawthorn effect may be on motivation of students to the computer simulation. It should be well understood that students interested in the topic in a simulated environment not the simulation itself.

VIRTUAL LABORATORIES IN HANDS ON EXPERIENCE STRATEGIES

Virtual laboratories (simulated versions of the hands-on labs) present a series of advantages, such as they are more cost-effective to implement and run, are not constrained by time or space, they are safe, etc. In science education virtual labs have emerged as complementary or alternative tools of the hands-on laboratory education.

Raineri (2001) supplemented the hands-on laboratory on molecular biology with a simulated version available on the Web. The main aim of the simulated lab was to provide the students with the chance of repeating the experiments many times so that they can acquire higher level skills and techniques in data manipulation and interpretation, which are usually very difficult to develop in the usual three hour classical hands-on laboratory sessions.

However, Raineri stresses the importance of the hands-on lab, pointing out that the simulated lab is rather a supplement than a replacement. Very similar conclusions were reported by Ronen and Eliahu (2000). They used computer simulations software to offer a supplemental version of an electrical circuit design experiment. They found that 70 percent of the students in the experimental group benefited from using the simulation by enhancing their confidence and patience during the hands-on sessions. The students who did not benefit from the simulation were either those with very high conceptual capabilities for whom the software formed no additional aid in the task, or those with very low understanding of the topic and who showed no interest in improving. Spicer and Stratford (2001) performed a qualitative study on the students' perception of replacing real field trips with simulated ones. The students showed very positive attitudes towards using the simulated field trip, but opposed the replacement of the real field trip with a simulated one. They valued using the latter as a pre- or post instrument to be utilized before or after the real field trip. After two years of combining computer simulations with hands on laboratory activities in life sciences. McAteer et al. (1996) concluded that simulations have granted the students better conceptual understanding; however, there is still a need for the hands-on physical skills, emphasizing that both modes are important and they are not mutually exclusive.

Lindsay (2005) studied the impact of the access mode to the labs, i.e., hands-on, remote, or simulated, on the learning outcomes. The results of the statistical analysis suggested that each mode offers different learning outcomes, and adopting hybrid access modes would enrich the learning experience of the students. Heise (2006) did a comparative study on students' performance in a digital logic lab, which was offered in both hands-on and simulated versions. Heise observed that students' motivation and interest increased dramatically during the hands-on lab compared to when the simulated experiments were used only. There is general agreement that simulations cannot and should not always replace the hands-on labs; however, they can be effective assisting tools. Engum, Jeffries, and Fisher (2003) performed a comparative study on using a virtual catheter lab versus a real catheter lab. The study revealed that both groups of students who performed the real or the virtual lab demonstrated the development of adequate skills; however, the students preferred performing the real lab. Engum and his colleagues suggested that a combination of the two methodologies may enhance the students' satisfaction and skills acquisition level

Design of the virtual laboratory experiment

Based on the goal-oriented design strategy, the students gain knowledge from the experiential of completing laboratory experiment. The virtual laboratory experiment should convey the information that the students need to master and refer to in the learning process. Examining the contents delivered by the virtual laboratory experiment, they are divided into text-based explanation, video demonstration of the procedures, plotting experimental results, learning outcome test, and interactively carrying out the laboratory experiment in a 3D virtual environment. To make use of both the features of 2D and 3D Windows, 2D and 3D Windows applications are employed to present these different types of learning materials in the virtual laboratory simulations. The 2D Windows applications include an introduction Window; help system and plotting Window for different learning goals. The 3D virtual environment provides students with realistic and interactive visual images and is used to simulate the laboratory in which the students can practice experimental skills.

Conclusion

Meaningful science learning will be possible when appropri-

ate practical experiences are provided for the learners. It is proved that the provision of adequate laboratories becomes mandatory for enhancing experimental skills among science learners. The Directorate of school Education of Government of Tamilnadu to make feasible for all its schools, care is taken that the laboratory curriculum does not demand costly equipment or other unrealistic requirements. For giving more importance for science practicals the Government of Tamilnadu has introduced science practical in the secondary level itself. In this connection if experiments were developed with the help of virtual lab method, it will be helpful for students and teachers to develop the desired skills in science teaching and learning especially in biology experimental skills. Virtual lab provides a chance for doing the experiment and hence resulting in a much higher knowledge retention rate than using the lab manual alone.

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