Virtual biology: how well can it replace authentic activities?

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Introduction

One of the debates within biology teaching is the appropriate use of animals and plants to enhance the learning experience. In particular, significant amounts of time are often set aside within curricula for relevant practical experiences, including dissections, drawings, microscopy, experimentation and discussions with peers and staff. An increasing number, albeit a minority of students are, for many reasons, disinclined to handle biological materials, while financial cutbacks are making the provision of them more difficult. This makes teaching the discipline using practical activities increasingly difficult.

Information and communications technology (ICT) in the form of computers, television, literature databases, and audiovisual materials have been available to teachers in all disciplines for many decades. So what is different about the high-tech learning environment of the 21st Century? Several factors have developed simultaneously to change the potential of IT as a learning tool. The most important is the ubiquity of computer networks, which has opened up the world of knowledge. Additionally, a convergence in digital technology has provided user-friendly multimedia instructional platforms, as well as the emergence of a cognitive learning theory which emphasises inquiry, and a marked change in the needs of society which has had an impact on the education process. Awbrey (1996) argues that educators need to encourage the work force of tomorrow to develop the skills of abstraction, system thinking, experimentation and collaboration. ICT provides greater educational flexibility by creating learning environments that are accessible to individuals with a variety of learning styles at anytime and anyplace. Technology can assist in overcoming barriers faced by students of all descriptions such as the distant learner or physically impaired. However, certain questions arise in this context.

- How do we include meaningful ICT experiences in the curriculum?
- How do we use computers to help our students learn?

The delivery of our large (approximately 1700 students in 2004) first year biology course at The University of Sydney has changed markedly during the last decade, to cope with an increasing heterogeneity of students. A starting point for this change was the introduction of computer-based learning materials in 1992. These are enhanced by delivery via a Virtual Learning Environment (http://FYBio.bio.usyd.edu.au/VLE/L1/) as seen in Figure 1. Resources available online (Figure 2) for the first year students include learning modules (tutorial-style programs), self-assessment modules (offering four levels of conceptual complexity or difficulty for self-assessment), lecture presentations, course information and web links. In addition many virtual learning experiences are available, which can be completed online in the laboratory, from home or from the University computer access centres. Included are virtual field trips, virtual microscopy, virtual dissections, virtual experiments and virtual communications designed primarily to enhance the hands-on learning experience of students. We have developed several of these modules to enable students to appreciate the skills required for a professional biologist.

Hands-on versus virtual biology experiences—advantages and disadvantages

The advantages of hands-on biology experiences are many and varied. With real laboratory materials students are obviously provided with a more realistic and arguably more stimulating appreciation of the biology. The real material is three-dimensional, it can usually be handled and used to stimulate group discussions and is the best way to develop the manipulative skills of the discipline such as

Figure 1. First year biology virtual learning environment (VLE)

dissections microscopy and use of scientific equipment. The disadvantages of using real materials are often managerial and cost-related. The materials themselves may be expensive to buy or collect, the laboratories have to be maintained and teaching staff must be provided. Other disadvantages are associated with the limited flexibility of the modern student. They are often not able to attend on-campus, for a variety of reasons and there may be ethical, ethnic or cultural considerations when working with biological materials.

The use of virtual biology experiences poses a different set of advantages and disadvantages. Virtual experiences can be obtained anytime/anyplace, and are usually experienced alone. They may be 'quicker' than traditional activities, such as field trips and experiments, which may suit many students. They may be less expensive to sustain as an activity, once the initial costs of production have been met. They may be used in a classroom situation by groups of students to help stimulate discussion and to develop communication skills and critical thinking skills. They may be available in the classroom as pre-hands-on 'training' or as an alternative (opt-out) for hands-on experiences such as dissections for students who have cultural objections to this. Ultimately, in some situations, virtual biology learning experiences may be better than the hands on learning experience.

Virtual field trips

A field experience re-created electronically allows students to take part in a time honoured biological learning experience in a more time and cost effective manner. We have used such programs in our bridging courses where it is not possible to take students into the field. This has provided them with multiple perspectives, by allowing them to access and collect information and construct their own understanding of the basic topics covered. Our experience of these activities supports Bitner, Wadlington, Austin, Partridge and Bitner (1999) who found that the use of virtual field trips increases students' abilities to solve real world problems. More recently we have tried to use a virtual field experience to involve students in data collection and provide background information to the real-world question which is more interesting and engages the student. In effect the field site for the investigation is brought to the students since it is impossible for them all to go to the field to survey and collect biological samples. When samples for the laboratory are collected we take along a camera to collect pictures of the site, sample areas, and show ecological conditions during the collection time. This may include video of sampling soil moisture. Students work in the laboratory with the samples and collect data for analysis, which is posted on the virtual field pages. They can then use the virtual information to help them interpret data and answer the original question. Everything can then be brought together in a class or online discussion.

Virtual microscopy for interpreting prepared microscope slides

It takes time and practise to develop the skills of microscopy to the level that the process of using a microscope does not impede the study of the biological material. Increasingly students are being shown the 'equipment', in this case a microscope, but they are not being given the time to develop the appropriate technical skills to make most effective use of it. In a general biology

course there are potentially hundreds of microscope slides of specimens that could be used by students. Here at The University of Sydney we have taken some of the ongoing it conceptually more difficult microscopy materials and produced a virtual tour of them. For example, we have dealt with the difficult area of cell division and producedsmall modules that consist of a series of photomicrographs of the process of cell division, each with a companion drawing and with the provision to add the labels to either the micrograph or the drawing. A small amount of descriptive text is available and the menu design takes the students through the material in a logical sequence which helps reinforce the cell cycle concept as well as the division process. For the students they have the advantage of consistent material and interpretation to be done anywhere/anytime. For us we are no longer required to provide and set up this very expensive material.

Virtual experiments

Virtual experiments, like virtual field trips, can offer students activities and exposure to content in ways that are not always possible in the classroom. Virtual experiments have been shown to provide a learning experience which is considered to be as effective as 'wet' practicals for knowledge and understanding (Hughes 2001). We have designed experiments that are integrated into the curriculum and can be used both by groups of students together in class or alone (at home) for revision. Experiments can be designed to generate data that is collected by a group of students for discussion or for writing a report. One of our experiments simulates the effect of light on photosynthesis looking at both the effect of light intensity and wavelength of light on the rate of photosynthesis of a plant. The students collect data from the simulations and then plot these data in their workbook. The experiments are simple in concept but would require multiple sets of expensive equipment to do in the classroom with such large numbers of students. The advantages of virtual experiments include the time factor (often the real experiment takes too long to generate sufficient data for a useful discussion to take place), their relative low cost in terms of materials, rapid data collection and potential to instigate group discussions in the limited time of the class.

Virtual dissections

The use of dissections, especially of mammals, is becoming more controversial, leading teachers and students to reconsider the value of these procedures in the classroom. In some institutions dissections have been abandoned, partially in response to 'animal rights' issues (Heron 1992). Alternatives to using animals for dissection are 3D models, slide-tapes, videotapes, videodiscs and computer simulations (Kinzie, Strauss and Foss 1993; Langley 1991; Quentin-Baxter and Dewhurst 1992; Strauss and Kinzie 1991). Also it has been shown that when students are offered an alternative to a rat dissection (like models and charts), their performance in examinations is no different from those students who completed the dissection (Downie and Meadows 1995). Several modules have been developed that can be used as alternatives for dissections.

We have also investigated use and usefulness, of a range of computer-based resources to students. Many of these investigations were designed to provide us with feedback for the ongoing iterative development of our own materials and a better understanding of how the students use the resources. These have been reported elsewhere (Franklin and Peat 2001; Peat 2000; Peat and Franklin 2002; Peat, Franklin and Mackay-Wood 1997). Prominent in these investigations are studies on the value of the resources in student learning, including the use of computer-based dissections in enhancing learning.

Conclusion

In answer to the question 'Virtual Biology: how well can it replace authentic activities?' the students are telling us that while there is an important place for virtual biology in its various guises, we must also provide authentic activities where possible. Hands-on laboratory activities are still the preferred activity in our courses and provide the key element in ratings of satisfaction with studying biology. Virtual experiences are valued for their flexibility of use, availability for revision and provision of additional information, whereas real experiences are valued for the hands-on, 3D nature but also for their 'reality'. If we wish to stimulate and challenge students about biology we consider that it is essential that they experience as much real material as possible within the constraints of time and budgets.

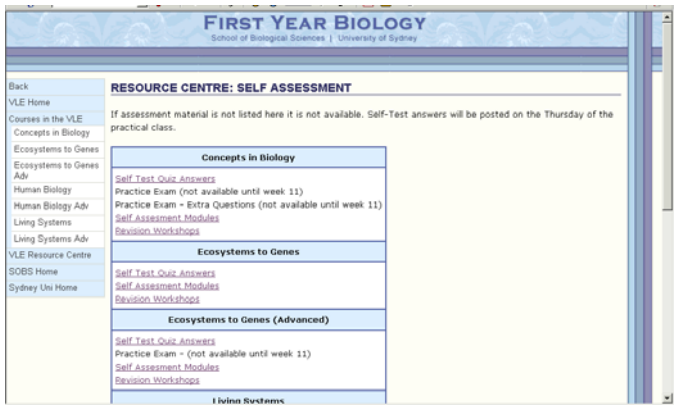

Figure 2. Online resources available in the VLE

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