INTERACT
INTEGRATE
IMPACT

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THE VIRTUAL LABORATORY: AN ONLINE PROGRAM TO INTEGRATE AUTHENTIC ACTIVITIES INTO THE BIOLOGY CURRICULUM.

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Abstract

We have created an online learning environment "The Virtual Laboratory" for the integration into the curriculum of authentic experiences for learners of biology at year twelve level. As part of a 2002 State of Victoria (Department of Education & Training) Science in Schools partnership we collaborated with teachers to design an online environment based on constructivist theories of learning. This was developed in a framework of cognitive interactivity. Students were given a scenario-based task and required to conduct a processes of enquiry by developing hypotheses, researching background, undertaking investigations and experimental work, then reflecting upon and refining their original hypotheses. In this way students were guided through the process of evidence-based enquiry. Interactivity and feedback to students operated at several levels to engage learners and enable students to gain control of their learning. A variety of techniques and media have been embedded in the environment, including digital images, animation, video, basic/advanced reading text and links to external web sites. Feedback is offered to address issues of problem-solving, knowledge and concepts. Subject areas addressed were Immunology and Gene Technology. Evaluation data indicates an overall positive reaction by students and teachers to "The Virtual Laboratory".

Keywords

Integration, interactivity, constructivist learning environment, online design and development, authentic experience

Introduction

For students undertaking biology at senior secondary level the realities of scientific pursuit and the application of theoretical knowledge to possible professions are often intangible. The curriculum in some areas is theoretically biased and teachers have little or no experience as practicing scientists. Through "The Virtual Laboratory" we offered authentic activities online supported by a variety of media to provide insight into the pursuits, values and culture of the professional scientist.

We created "The Virtual Laboratory" as an online learning environment based on constructivist theories of learning (Honebein *et al.*, 1991). We addressed educational design goals of constructivist learning through the development of authentic activities (Herrington & Oliver, 1995) with a problem-based learning approach. These goals encompass: providing multiple perspectives (Cognitive Flexibility Theory), embedding of content in an authentic context, engaging learners in authentic activity and providing thematic links across domains (Situated Cognition), tasks that enable learners to collaborate (Distributed Cognition) and the use of tools that increase awareness of the learning process (Generative Learning Theory) (Bannan-Ritland *et al.*, 2001).

This provided a framework for cognitive interactivity where students had a sense of purpose. Further dimensions of interactive elements were considered at the levels of learners (e.g. a focus on navigation, making choices, prompts), content (frequency, choice of media, layering level) and pedagogy (a focus on learner style, pace and control, problem-solving) (Sims, 2000).

"The Virtual Laboratory" contained two modules that were designed to enhance the teaching and learning of two year 12 Biology units; *Immunology*, and *Gene Technology and Its Applications*. Disease was the module that focused on the basic principles of immunology underpinning host-pathogen interactions, while Gene Technology focused on the molecular basis of commonly used biomedical tools. Teachers had identified both these areas of the biology curriculum as being particularly challenging for students, and which were supported by very few resources. A text-based teacher's guide included details about the philosophy underpinning the program and its educational design.

Educational design and architecture

In the design phase of the project we consulted with teachers to identify aspects of online pedagogy appropriate for students and which teachers could support and sustain. This provided a valuable phase of pro-active evaluation (Sims *et al.*, 2002) addressing the fact that as practicing scientists and educational designers we did not have direct contact with the target student audience. Ongoing formative evaluation was carried out with teachers as the project developed.

Through this process we adopted an online mode of delivery of content and activities via html pages with embedded media elements, automated feedback on request and user text input. Aspects of interactivity relating to online discussion and automated assignment submission were not sustainable across many schools and these features were not integrated at this stage. The design of adaptive feedback loops was refined through both pro-active and formative evaluation phases.

Authentic context was embedded initially through the homepage. A stylized visual representation of a research laboratory is presented. Mouse-over effects highlight significant equipment with zoom-in imagery and explanation. This was further supported throughout the site with images and video sequences of scientists performing specific techniques.

Student projects were written around real-life scenarios providing authentic activities for students. For example, a scenario used to introduce students to the technique of Single Nucleotide Polymorphism (SNP) was *"You are a scientist working in a laboratory that frequently uses SNP genotyping to screen patients for genetic disorders. Your first priority today is to test five blood samples from individuals suspected of having the genetic disorder Wolff-Parkinson-White (WPW) syndrome - Find the individual with a mutation causing WPW syndrome"*. Students were guided through an investigation in a sequence of steps elucidating the process of analysis and scientific method.

These steps were: ***Hypothesis Formulation, Methodology, Data Collection, Data Analysis & Interpretation, Reflection, Prediction, Conclusions*** and ***Medical Closure*** of the scenario. For example methods including isolation of genomic DNA and automated gel electrophoresis were described and explained with text and animation (Figure 1). Students were given chromatograms resulting from the use of these methods and were asked to convert the chromatograms into nucleotide sequences (Figure 1). They were then guided through alignment of their own derived sequences using a simulation of an

Internet-based program (ClustalW), identification of mutations, confirmation of mutations by determining which amino-acid is affected. Students then applied what they had learned in the simulation by using the 'live' ClustalW database online to align new sequence which they derived from new chromatograms. Students were asked to reflect on and refine their hypothesis in the light of their results, make predictions through integration of their understanding of the genetics of the syndrome and sum up their investigation.

To complete the investigation students needed to explore the scenario from multiple perspectives. For instance they needed to understand the syndrome (e.g. symptoms, genetics, outcomes) and methods used (e.g. biochemistry, technology) and the link between them. Content elements were linked to the underlying rationale to optimize interactivity with specific focus on the learner. Resource material was available in a variety of forms and media, and delivered in layers of increasing complexity. Students were prompted to access content and were guided to clarify their need. This was designed to increase their independence as learners (they actively requested content); and their discrimination (to know what they want and when they have found it).

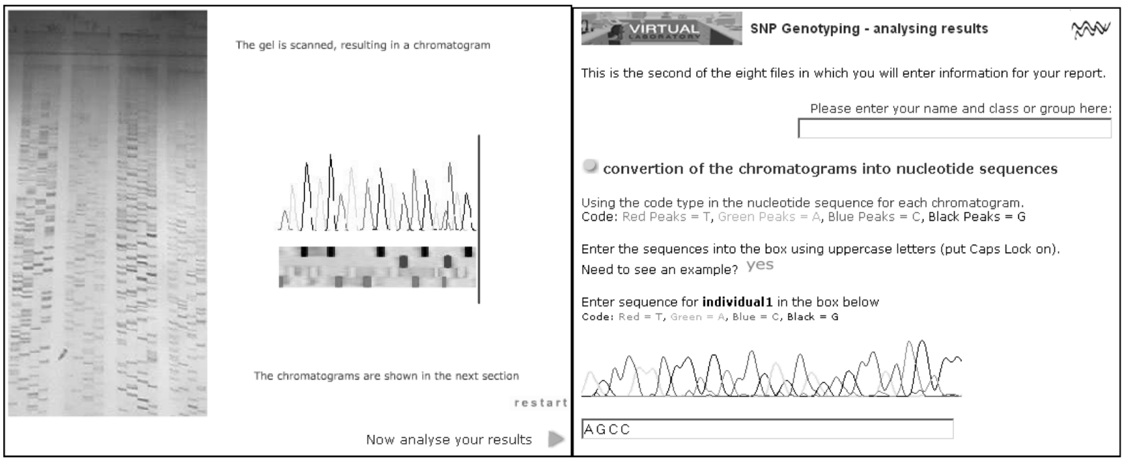

Figure 1: Animation of method of data generation & Analysis and interpretation of data

Use of Technology

The online environment offered an opportunity to collect, contain and layer content for interactive delivery to students. Content offered in a variety of types of media including images, video, audio, animation, dynamic web pages, text and links to websites, enabled the presentation of multiple perspectives.

The analysis of the scenario was presented in a series of web pages with text input forms into which students typed responses to tasks and questions and recorded their thoughts, ideas and experimental data (Figure 1). In completing the tasks students can compile a scientific report which replicates the layout of a scientific publication. Students can print out such a report to submit for assessment. Through this investigation the process of scientific research and communication is made more transparent to students. Explanations, hints and feedback were given via mouse-over, pop-up windows, embedded animations and links.

Implementation and evaluation

The Disease module was the first module of The Virtual Laboratory to be produced and was used in five schools in the Eastern Metropolitan Region, during April 2002. The second module Gene Technology was used in two schools in September 2002, and was assessed by three teachers from the Barwon South Western Region for future use in their classrooms.

Student and teacher evaluation of the Disease module of The Virtual Laboratory was carried out, with forty-three questionnaires returned from a total of five schools. Data from these questionnaires indicated an overall positive reaction by students with 68% agreeing or strongly agreeing that using the module was an effective method to develop a comprehensive understanding of disease. Comments about the best aspects of the module reflected the quality of information, the fact that all relevant material was packaged into one site, and the effective use of visual effects (including color, images, animations, and video). Evaluation of the Gene Technology module was carried out via questionnaire by five teachers (located at different schools) and one class of 19 students. The responses from teachers indicate a generally positive attitude towards the module. Data from student questionnaires were inconclusive, but highlighted differences to responses of teachers, which may reflect a greater familiarity with online activities by students.

Conclusion

A critical analysis of the characteristics of The Virtual Laboratory suggests that it provides an authentic context in which the trainee scientist can investigate real-life projects. The integration of media within the online environment and the integration of the online environment with the curriculum were important aspects of design and implementation. The extent of integration into the curriculum is dependant on teachers valuing and implementing the online environment. The Teacher's Guide provided supported for teachers in appropriate adoption and implementation. Multiple levels of interactivity, encompassing issues of context, content, understanding, knowledge and problem-solving, engages learners and enables them to gain control of their learning. Further integration of themes across subject areas involves design and implementation of activities which draw together fundamentals of disease and gene technology.

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