Videoconferencing for a Sustainable Future: A Technological Option for Science

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The issue of sustainability is one of considerable concern to all sections of society in our rapidly globalizing world. The question of how does one ensure the long-term survival of industries and institutions is one that much preoccupies managers and employees in today’s world. This question is of no less interest to educators than to any other industry. There is little doubt that many small departments in Australian institutions are struggling to survive in the current environment. However, technology can provide viable solutions.

The 1997 CUTSD grant awarded to a team of academics from Central Queensland University and Deakin University, entitled “The Role Of Videoconferencing in Enhancing Teaching/Learning Via a Virtual Faculty” investigated the feasibility of developing virtual faculties for the teaching of upper undergraduate, honours and postgraduate chemistry specialisations at regional and remote universities. The project was also concerned with the issue of retaining students within their local institutions and thus within their local communities upon graduation. Staff and students from Central Queensland University, Northern Territory University, Deakin University and the University of Tasmania participated in the development and realisation of the “Virtual Faculty”. Particular universities collaborated in offering content areas from their chemistry courses that were not available in other participating universities. This provided a unique opportunity for students to broaden their general understanding of the discipline as well as acquire specific, very specialised knowledge.

The project demonstrated that videoconferencing can provide a viable environment for developing a virtual faculty, inspite of its current comparative technological fragility. While technical problems are a real issue, students tend to value both the broad and general learning opportunities presented to them, and thus are generally fairly forgiving of technological breakdowns. Students were pleased with the opportunity to participate in a wider range of subject offerings while remaining at their local institution. Staff also valued the opportunity to teach to a wider audience and to gain valuable skills in using videoconferencing effectively as a teaching/learning tool.

With a wide range of delivery options now becoming available through developing technologies, there is greater opportunity to choose the delivery option on the basis of the learning need of the students and appropriateness of the content. For this particular project, videoconferencing was chosen as the medium of delivery because it was felt that it was most suited to the needs of the students and the subject matter being taught. As many of the concepts to be taught in the subjects offered were considered difficult for students to understand it was felt that students needed the opportunity for real time interaction with both lecturers and peers and immediate feedback in order to come to grips with the subject matter. It was felt that neither web nor print-based distance learning materials would provide the appropriate learning opportunities for these subject areas. (Brown, 1998)

Where very small groups of students are working alone in relative isolation, virtual faculties can expand the student group thus providing real opportunities for increased peer interaction. However, this interaction doesn’t just happen and needs to be carefully designed and fostered which can require a rethink for both staff and students. For staff there is a need to rethink the curriculum design. There
is a need to understand the characteristics of the new learning environment and the way in which this impacts on the delivery of the subject. People such as Bates, (1995); Laurillard, (1993); Klease, Andrews and Druskovich, (1996); and Burke, Lundin and Daunt, (1997) comment on the problems of transferring existing teaching approaches to new media, the “old wine into new bottle syndrome” and the usually unsuccessful outcomes of taking such an approach. Many teachers and lecturers report unsatisfactory results with using videoconferencing and other technologically mediated forms of teaching and learning and this can be seen as an outcome of the difficulty in adapting to the demands and characteristics of the new environment. Students too, may experience difficulties with unfamiliar forms of teaching and learning. They may be ill prepared for the teaching and learning strategies they encounter and feel intimidated by both the technological environment and the kinds of activities they are participating in.

In utilising technological tools, the need for appropriate staff development and adequate student preparation is paramount. Staff need to have the opportunity to develop a thorough understanding of this new teaching and learning environment and its particular characteristics. There is also a need to develop an understanding of new teaching and learning strategies that better fit this environment and the ways in which the environment can be utilised to improve learning outcomes for students. The use of technology tools also highlights the changing nature of education and the increasing team involvement required for effective development of teaching and learning materials (Berge, 1998). Students also require assistance in coming to grips with what for many of them is both new technology and unfamiliar teaching and learning practices. Adequate student preparation programs and activities are an essential part of successful use of technology teaching tools.

Institutional support is yet another element in effective utilisation of technological tools. It is essential for such ventures to receive support at all levels of the organisation, if they are to be successful. Ventures such as this need to mesh closely with the strategic direction and priorities of the institution. In this way appropriate support, technological requirements and funding needs are seen as a matter of course, rather than a drain on institutional resources. Without institutional support, such ventures are unlikely to be successful.

ISDN (Integrated System Digital Network) or microwave based videoconferencing (as opposed to desktop videoconferencing) is a powerful tool in the flexible learning arsenal and can be effectively used to create both flexible learning environments and virtual learning environments. Additionally, tools such as videoconferencing allow for the exploration of more student centred learning activities than those commonly encountered in more traditional environments, particularly in areas such as Science, where the lecture/tutorial model of teaching based on the transmission of knowledge is still most generally used.

References
Using Mathematical Packages in Advanced Science and Engineering Units

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Introduction

Much of the subject material in high level science and engineering units is strongly based on advanced mathematics and requires a high level of mathematical skill on behalf of the students. This is particularly true of subjects like Signal Analysis, Electromagnetics and Control Systems. These skills are usually acquired during the mathematical strand of the course.

Previously, assignment problems presented in these subjects had to be solvable by hand, that is with algebraic manipulation and a calculator. This has two distinct consequences:

• For realistic problems, more time is spent on advanced but routine mathematical manipulations than on the conceptual principles of the subject material; and

• Problems that are solvable by hand (the problem must be carefully posed such that the solution will drop out in analytic form to second order, i.e. quadratic) are necessarily highly theoretical, simplified and unrealistic.

For these reasons it was thought that the routine use of an advanced mathematical package would transform these subjects from a mathematical slog to a higher conceptual level with the student putting the intellectual effort into mathematical formulation and analysis of problems with the package performing the mathematical grind. The use of such a package would address both of the above problems in that more time would be spent on addressing the conceptual material and would allow more realistic and complicated problems to be posed and addressed.

The Project

The project really began in 1996 with the development of some Mathcad worksheets for the Signal Analysis laboratory. There is a wide range of mathematical packages (Matlab, Mathematica, Maple, C4, etc.). Mathcad was chosen since, at the time, it was the only such package that “looked like” mathematics on-screen rather than a programming language and produces readable documents. The success of this pilot work led to an application for funding of this project through the University of Canberra Teaching Grants Scheme. A full set of worksheets and lecture demonstrations would be developed for the Control Systems subject, and also some worksheets and demonstrations, but not a complete set, for the Electromagnetics subject. The Control Systems work was considered a priority since it suffers significantly from the perception of being “maths-in-disguise” even though it is conceptually rooted in physical systems.

A second aspect of the project was that of flexible delivery. The use of any computer package and its associated electronic documents will have flexible delivery implications. The implementation of the materials produced in this project was to be used to assess the flexible delivery possibilities of such material and presentation.

The School of Electronics Engineering and Applied Physics funded the purchase of a 20 license laboratory set of Mathcad 5 for student use in 1996. This was upgraded to version 6+ in 1997 to allow this project to be tested in the laboratory. The introductory laboratory worksheets for Signal
Analysis were used in semester 1, 1996, 1997 and 1998; the Control Systems material was used in semester 2, 1997 and 1998 and the Electromagnetics material was used in semester 1, 1998.

Achievement of Project Objectives

- **Devise a short training course in Mathcad to be used at the second year level such that students have the basic skills to be able to use the package effectively.**

The introductory worksheets used in the Signal Analysis laboratory work are effectively the training course. This set comprises an introductory supervised computer laboratory session in which the student uses the tutorial provided with the Mathcad package along with a few simple tasks to get used to the look-and-feel of the package and, in particular, the typography of equation entry in the worksheets. The student is then presented with three pre-prepared laboratory worksheets. The students use the worksheets for making specific calculations and modify the worksheets to perform other analysis. The introductory session has been modified in the light of experience but is still unsatisfactory. The package is significantly different from what the students have been exposed to by way of computer tools and it appears that they need a more structured and systematic approach.

- **Gradually introduce Mathcad into the engineering course starting in second year with training and light use and then fully in third year engineering units.**

As a direct result of this project, Mathcad is now in formal use in the subjects Signal Analysis (2nd year), Control Systems, and Electromagnetics (both 3rd year). In addition the Mathematics staff are using it formally in the unit Numerical Analysis (3rd year) again for the reason that it is easy to read (like mathematics) but can perform complex numerical and algebraic tasks. The package is also used informally in Electronics Engineering 1 (1st year) and Electronic Instrumentation (4th Year). In addition the students who have been exposed to it tend to use it in all their units that require any mathematical analysis of any complexity. In particular they use it in their design projects for simulation purposes as they find it is much easier to use and more readable than programming in a standard computer language.

- **Devise a set of lecture demonstrations using Mathcad to dynamically illustrate the concepts under consideration.**

- **Devise a set of assignments and problems for selected modules of the third year engineering units that are realistic and that can be solved using the advanced features of Mathcad.**

A complete set of worksheets, assignment questions and lecture demonstrations have been developed for use in the subjects Signal Analysis, Control Systems and Electromagnetics. These materials were developed with the help of a recent graduate who was employed to construct the Mathcad documents from drafts and ideas developed by the author and the graduate. They have been used on several occasions and have been further developed in the light of evaluations from the students.

- **Evaluate the effectiveness of the use of the package in improving student performance and enthusiasm for what are highly mathematically based subjects.**

Evaluation of the use of Mathcad in these subjects was undertaken by surveying the students. The first survey was given to the students of Signal Analysis at the end of semester 1, 1996 after having been exposed to the trial use of Mathcad. Responses to selected questions are shown below.
The results indicate that the students feel that the use of Mathcad does help their understanding of the lecture material and that they found it relatively easy and enjoyable to use. There is strong support for Mathcad to be used in other units but, notably, only about half the students used Mathcad outside this unit. This is not surprising as it is their first exposure to the package.

A similar survey was carried out on the (fewer) students in Control Systems in 1998 after this project was complete. These students have now used Mathcad in three units in 2nd and 3rd year and are reasonably well versed in its use. Again the results indicate that the students feel that it is useful and does help understanding. Now, after two years use, the large majority of students are using Mathcad outside the units that formally use Mathcad. This is borne out by assignments that are not set in Mathcad being handed in as Mathcad worksheets and in particular in the number of students using Mathcad for complicated analysis in their 4th year projects.

- **Assess implications for flexible delivery of mathematically based subject material.**

The implementation of the project attempted to be flexible in that the students did not have to submit paper copies of their work. Indeed, because Mathcad worksheets are live, printing them defeats their greatest advantage. The assignment worksheets were posted on the unit web site so that the students could download them and work on them either at home or on the University network. Mathcad in fact has a built in web browser that automatically opens recognised Mathcad documents from the web. Assignment answers could be emailed to the tutor either directly from within Mathcad or as a standard attachment. The worksheets remain live so that the tutor can inspect, mark and annotate them and return them to the student. Complete worked solutions are posted after the due date. Similarly all lecture demonstrations were posted on the web so that the students could download and operate the demonstrations themselves.

This system worked well and was appreciated by the majority of students, particularly part time students. A few preferred to submit hand written solutions using Mathcad only for the final calculation and plotting. Once again this really defeats their purpose since any changes will have to be worked by hand and re-entered into the worksheet. These students are usually those who have not taken the time to become fully acquainted with the typography of Mathcad indicating again that better initial training in its use is required.

In the coming year further uses in flexible delivery will be investigated by including Mathcad worksheets in a WebCT site for the unit. The web can be browsed from within Mathcad and there is
a wealth of information, applications and discussion groups at the Mathcad Collaboratory site (http://webserve.mathsoft.com/mathcad/). A further tool is the existence of many electronic reference books that can be used from within Mathcad. These are relatively cheap, are live and can be edited to suit. They cover a wide range of science and engineering subjects.

**Conclusions and Recommendations**

All the objectives of the project have been achieved. Both formal and informal feedback from the students has been universally positive, many students purchasing a copy of the student edition of Mathcad ($99) for themselves. Students are using Mathcad for analysis and design work even when not formally required; it produces mathematically readable documents. The author now uses Mathcad for preparation of demonstrations and worksheets in all units that he teaches and the use of Mathcad is spreading to other units in the School and in the Faculty and is also being used by research staff for modelling purposes.

In order to extract the maximum benefit from the investments in the software and in the development of the materials to use it, the following is recommended:

1. That some time, early in the course, be allocated for formal training in Mathcad. The tool is useful and appreciated by the students, but a short tutorial session is not adequate to allow students transparent use of the package.

2. That a Staff Development program should be established to ensure that all appropriate staff are Mathcad literate. This will generate further expansion in the use of the package as well as generating efficiencies in the setting of assignments etc.

3. That further work be undertaken to evaluate the use of Mathcad in flexible delivery programs. The latest version of Mathcad (Version 8) is fully web compliant and offers wide possibilities in a flexible delivery program. These will need to be investigated and evaluated.

**Acknowledgement**

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The Future of Multiple Choice Questions in Learning:
Formative Assessment, Interactive Teaching Modules and
Student-created Questions within WebMCQ

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Introduction

Multiple choice questions (MCQs) have become increasingly prevalent in modern education. The potential for automatic processing of MCQs has encouraged their use in educational testing in a wide range of contexts, including secondary and tertiary level education aptitude testing, formal examinations, and also as part of surveys and attitudinal measures. The use of computers in this processing has been substantial, with optical character recognition (OCR) and direct computer based examinations being major contributors to the rise of this method in modern educational practice. The ability to test large numbers of students using computer based marking systems has helped ease the marking burden of teachers involved in large courses, a problem common to many early undergraduate science programs.

More recent developments in this field have seen the rise of web-based assessment systems, such as WebMCQ. These systems combine the advantages of traditional computer marking with the flexibility in time, place and pace of Internet delivered educational materials. Student evaluations of web-based materials, particularly where these are provided for practice prior to formal assessment (Dalziel and Gazzard, 1999), are extremely positive. Student feedback indicates that the ability to “get a feel for the test” (using practice questions), immediate feedback on incorrect answers, multiple layers of feedback, and the ability to use the system when and where they choose are among the reasons for these positive responses. Where formal exams use the same computer systems as those experienced earlier using practice questions, student familiarity with the interface should help to lessen exam tension and anxiety. Students using these systems for formal tests also appreciate the ability of these systems to provide final scores immediately upon completion of a test.

Web-based systems can offer new advantages to teachers as well, particularly where the entire process of creating, presenting and monitoring MCQ material is available over the web. By centralising all materials, and providing a system for editing questions and monitoring student usage, web-based administration tools can substantially reduce the burdens on teaching staff related to the implementation of computer based MCQs. As systems of this kind evolve in this area and elsewhere in educational courseware, easy to use web tools will help teachers to focus more on content and less on technical requirements (such as new programming languages, web site maintenance, knowledge of TCP/IP, etc.). This evolution in educational software systems should help teachers to spend more time on the task of teaching, and less time developing and testing software.

The use of MCQs in fostering student learning

WebMCQ is one system that has taken advantage of the major shifts in education and computing described above so as to aid teachers in the development of educational assessment material. For a description of the system and its development, see Dalziel and Gazzard (1998, 1999) or visit http://www.webmcq.com/. However, in the process of developing and implementing MCQ assessment material with a range of education and training partners, it has become clear to the authors...
that MCQs have much wider potential application than just testing. While using MCQs in the testing of existing knowledge in some kind of assessment format is well established in education, we see new avenues for the use of MCQs in learning within education. This new branch of MCQ usage, where MCQs are used as a primary basis for encouraging student learning, rather than merely as a method for testing existing knowledge, is a new possibility encouraged by web-based implementation of MCQs. Three examples of the use of MCQs in learning are described below, although the first of these (formative assessment with multiple layers of feedback) is an existing method that can be classed in both testing and learning categories.

**Formative assessment with multiple layers of feedback**
The original success of WebMCQ was based on practice questions provided to First Year Psychology students prior to an end of semester test (Dalziel and Gazzard, 1998). These practice questions did not simply give correct or incorrect responses, but rather provided this and two levels of feedback about each question. The first layer of feedback indicated specific information about the question and why certain answers were correct or incorrect. The purpose of this layer of feedback was to provide information particular to the question to assist those students who may have given an incorrect answer, but who understood the question sufficiently to grasp the nature of the mistake they had made once feedback was provided. But in designing this feedback, it was clear that some students would not understand the initial reasons given for the correct/incorrect answers, and other students may not understand the topic at all due to lack of study. For this reason a second, more general level of feedback was provided to discuss the issue raised by the specific MCQs in a more general way. This feedback was designed to help students still struggling with basic concepts, and would sometimes include further references to handbook material or additional resources such as relevant textbook sections.

Student evaluations of this material indicated that both self-testing and self-teaching was occurring. Some students used the questions only after study of existing handbook notes and related material, whereas others started the process of study by using the questions and feedback provided as a basis for learning. Many students combined both of these methods, with the average number of sessions in which WebMCQ material was accessed (across all students) being more than two times (some used it more than ten times). Feedback indicated that students valued the multiple layers of feedback as a way of understanding both the specific issues of the question, and the more general issues raised by the relevant topic area. The following evaluations from a set of practice questions for a 1999 Social Psychology lecture series support these findings. In answer to the “best thing” about the material, students responded:

- “The feedback given once the question was answered would probably be the best part. Knowing where you went wrong and understanding the correct answer is quite helpful.”
- “Explanations are thorough for both right and wrong answers . . . [the] notes relate to theories looked at in lectures.”
- “[WebMCQ] provides answers concisely with additional information as well as the ability to print out the question, answers and feedback for revision.”

**Interactive question teaching modules**
While formative assessment can combine both teaching and testing, it is possible to use the MCQ format as a primary instructional vehicle. While traditional methods of disseminating content rely on relatively passive methods (such as reading text or listening to lectures), a teaching module based on MCQs has the potential to be far more active in its engagement of student learning. If regular questions about current learning, new ideas and contentious issues are provided for students within an instructional module, together with subsequent feedback on the issues raised and provision of new instructional material, then MCQs can be a basis for entire interactive teaching modules. These MCQs need not have right or wrong answers in all cases, as questions which force students to choose
their own view of a contentious matter can then be used to help students reflect on the relative strengths and weaknesses of other views when given appropriate feedback. As WebMCQ and other similar systems can incorporate pictures, sound, movies, etc., it is possible for either questions or answers (or both) to incorporate the best aspects of multimedia training under the umbrella framework provided by the familiar MCQ structure.

By adopting this approach, whole teaching packages can be developed without the need to learn special programming languages or authoring systems, and given the multimedia options possible, these packages can be as rich as traditional computer assisted learning (CAL) systems, but without the difficulties in dissemination, creation and subsequent editing. An example of this approach to instruction is currently being developed by the authors for a guide to writing good MCQs, in which aspects of good question design, pitfalls to avoid and common misunderstandings about MCQs are all addressed within a teaching module that uses MCQs as a method for teaching about these issues. This guide should be available later in 1999 from the main WebMCQ web site.

**Student-created MCQs**

MCQs have long been derided as being incapable of testing higher levels of learning. While this may be true of many practical examples of MCQs in education, it is by no means a necessary phenomenon – well written MCQs can test some of the higher order types of learning such as application and analysis. However, it is difficult to see how traditional usage of MCQs can test the highest levels of learning such as broad-ranging synthesis and evaluation of knowledge, and especially, creativity.

However, a newly developed feature of the WebMCQ system may change the way this issue is considered in the future. This feature allows teachers to create student workgroups with limited access to the same web-based creation tools used by lecturers. Using this approach, teachers may allocate designated areas where students may create their own MCQs for other students to access for self-testing or later discussion. Students can provide feedback as well as designate correct and incorrect answers. This approach is expected to allow higher order learning (especially creativity) due to the fact that for students to create MCQs, they will need to synthesise their existing knowledge, form this into a testable question, and produce both a correct answer and plausibly incorrect answers (to this can be added feedback designed by the student if so desired). The process engaged in by the student would produce a qualitatively different learning experience to that produced by typical MCQ testing, and this process can be used in the classroom to allow students to view each others’ questions and to consider any problems that arise with the student-created questions.

This is an innovative use of MCQs, and evaluation of this approach is currently underway, but initial student feedback is positive. There are a variety of ways in which student created MCQs can be applied in education, some of these include: individual versus group question creation, how students reacted to combined sets of teacher and student created questions, whether feedback on questions is required, whether question creation is optional or mandatory for all students, whether student-created questions may be subsequently used in formal testing, and so on. We expect the next few years will provide a rich source of options for the effective use of student-created MCQs in the learning process, and that this, together with the other uses outlined above, will vastly extend the range of educational uses of MCQs.

**References**


Overview

From 1993–1997 the subject “Introductory Immunology” was delivered in “traditional” mode with 3 hours of lectures and 3 hours practical/tutorial classes per fortnight. However, it was believed that this structure provided little opportunity for students to develop as independent learners (Candy, Crebert and O’Leary, 1995), nor did it help them to develop the skills and attitudes that are essential in graduates such as critical analysis, problem solving, communication and working in teams (B/HERT, 1992; NBEET, 1992). Typically, students enrolled in this subject were used to a teacher-led learning regime and not usually familiar with group learning as an educational technique and, although students worked in small groups (n=2 to 4) during laboratory sessions, the groups were often friendship partnerships and provided little opportunity for cooperative learning.

In 1997 we undertook an evaluation of the effectiveness of the existing delivery methodology, both from the viewpoint of the skills it aimed at developing and from the students’ perspective. In 1998 the subject structure was changed from its traditional presentation mode to group work, use of reflective journals and workshops. Student opinion was canvassed during this period with respect to their expectations, their concerns and their preference for particular learning modes.

Subject delivery

The content and concepts of immunology were delivered by audio tapes, study guidelines and brief lecture notes, instead of traditional lectures.

Evaluation

Effectiveness was examined from two perspectives:
1. The students were surveyed three times during the semester.
   1. Entry survey: administered at the beginning of the semester canvassed students expectations.
   2. Progress survey: conducted at the conclusion of an early workshop session. This survey sought to explore the students’ initial perceptions about the benefits and disadvantages of the newly implemented teaching and learning strategies.
   3. Exit survey: administered at the end of the semester. This survey canvassed student study behaviour throughout the semester and sought to identify areas of perceived benefit and/or weakness and opinions about the subject structure.
2. Quantitative comparisons were made between assessment results achieved via the traditional teaching approach, from the previous year’s cohort of students, and the new methodology.

Outcomes

Student perceptions

Survey 1: Entry survey
If given the choice, 89% of students would have chosen to do immunology, either out of personal interest (44%), because it was good knowledge to have (28%) or a prerequisite for their chosen career path (39%), or simply because it was perceived to be enjoyable (11%). Expectations about the subject varied, the largest number of students (48%) expected to gain an understanding of how the immune system functions or be given a solid background in immunology (33%).
Survey 2: Progress survey

The second survey was undertaken four weeks into the program. At this stage, student opinion about how well the combined strategies aided understanding ranged from poor (9%), through to adequate (41%) and well (38%) whilst a small number thought the new strategies worked very well (12%).

Opinions varied about the effectiveness of the tapes as a source of information, though 50% thought they were either effective or very effective, and a further 35% perceived them to be adequate. At this stage in the semester, 71% were using their textbook as a resource, but of these only 52% believed it to be effective or better. Students also varied greatly in their opinion of how well the group discussion/workshop format helped understanding, the majority (88%) were positive, thinking they worked adequately (24%), well (44%) or very well (20%). A large majority (91%), were impressed with how well their groups had functioned thus far.

However, when asked what parts have proved most difficult, 32% had complaints about the audio tapes, specifically the length of time required to listen and take notes, the lack of interaction with the lecturer and the quality of the tape itself. A small number (18%) experienced difficulties due to a perceived lack of time in which to do the work.

Survey 3: Exit survey

When asked how effective each of the delivery strategies used during the semester had been in aiding learning in immunology, students felt that the regular quizzes were the most effective learning strategy with 86% ranking them good to very good. Over half the students were supportive of both the audio tapes and assignments (59% good or very good).

The reflective journal was not favoured. Only one student always used it, with 68% either only using it sometimes (50%) or never at all. Student attendance at the workshop session was not officially recorded, but student feedback indicated that little more than half (59%) always attended, with a further 32% attending most of the time. Of those who participated in the workshop sessions, 86% stated that they always (41%) or mostly (45%) engaged in the discussions.

Group work was only popular with a few students (18%). The workshop sessions requiring group work were found difficult by some (32%) as:

- working in groups increased confusion for some students;
- students didn’t use their time effectively during these sessions;
- discussion was limited as not all students listened to the tapes prior to class;
- work undertaken in the sessions was too predictable; or
- was perceived as less important than other aspects of the curriculum.

Suggestions for change included the reintroduction of lectures (27%), the introduction of a tape/lecture combination (9%), summary/plenary lectures (9%) or increased lecturer input during workshops (9%). Other suggestions included a finetuning of the workshop and group work format (14%).

Comparisons of student grades

The spread of student grades from the Phase Two students showed a typical spread as shown in Table 1.

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<td>1998</td>
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<td>12</td>
<td>21</td>
<td>18</td>
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</tr>
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Table 1. Grades received by students (%) in the two cohorts of students in 1997 and 1998
Content complexity and delivery strategies

Much of the dissatisfaction expressed by the students about their study of immunology, either by way of the traditional or the new approach, may in part, have been due to the level of complexity of the material covered. Almost 60% of students felt that audio taping of lecture material was effective, many appreciating the ability to refer to tapes again when studying for exams. Though the most favoured approach was the workshop quizzes, probably because they allowed students to get regular feedback about their level of understanding and to gauge what aspects of immunology the lecturer deems most important. This is also indicative of the weight many science students place on summative assessment. Student preference for delivery strategies was quite divergent, indicating the variation in individual learning styles and preferences that can exist in one class.

Reflective and experimental journals

As so few students completed the reflective journal assiduously, it is impossible to comment about the effectiveness of such a learning strategy. Journal writing as a learning strategy is not common in the sciences, although working scientists would employ such a practise in documenting their laboratory endeavours. The experimental journals enabled students to practice the skills of documenting scientific procedures, and the thought processes that a scientist must cultivate. It is suggested that a more effective structure be developed for the journal to serve a dual purpose: exploration of the subject knowledge base and articulation of the underlying rationale of laboratory work.

Workshops

The workshop sessions were not as successful as anticipated. There were three major reasons for this:

• students lacked the training in group, teamwork and communication skills;
• teaching staff needed more resources to call on in order to get students to be active in their learning; and
• these sessions required students to be more actively engaged in the process of learning and carry a greater load of responsibility for directing their own learning, not all students were ready or willing to cooperate.

Conclusions

The restructuring of “Introductory Immunology”, involved a more student-centred and resource-based learning regime which incorporated audio taped lectures, student-led workshops and journal writing. It was anticipated that this approach would produce learners who were more actively engaged in the process of learning, carrying a greater load of responsibility for directing their own learning.

It is concluded that such objectives can only be achieved if both staff and students have a clear understanding of the benefits of the learning approach and a willingness to undertake new roles and responsibilities and finally the knowledge of “how” to effectively change their learning styles.

References


A ‘Community of Learning’ – the UWS Nepean Science Virtual Resource Centre

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Introduction

The Science Virtual Resource Centre (VRC) (http://edtech.nepean.uws.edu.au/science/vrc/) has been modelled on web sites that are already successfully engaging students, notably The University of Sydney’s Biological Sciences site (http://fybio.bio.usyd.edu.au/sobsfyb/fyb_StuRes.html) and Hypertext Books at the College of DuPage (http://www.cod.edu/dept/KiesDan/).

The site was established with six main aims:

• to provide level one science students with greater access to learning resources and information, and encourage the use of technology as a learning tool;
• to free staff from being seen solely as information providers, enabling them to have access to a venue through which they can experiment and develop rich and interactive learning resources;
• to establish a site where collaborative learning is encouraged and supported, and where teaching staff can challenge and stimulate students;
• to assist students to develop the skills of independent learning, encouraging them to take responsibility for their own learning;
• to help students develop their computer skills and familiarity with the web, via an easily accessible, low technology site; and
• to begin the development of a ‘community of learning’ (Hough and Paine, 1997) whereby students and staff share common learning interests and purposes.

The VRC site was launched in first semester 1999, and is thus in its infancy. Subject Resources, Further Tools for Learning, and the Discussion Forum, are still being developed. The process by which the site has developed, and continues to evolve and the manner in which we hope to achieve our aims will be the focus of this paper.

Access and usage of the technology as a learning tool

In a survey of level one science students, it was found that only 48% of students are regular users of computers, though 66% reported feeling either very confident or fairly confident when it comes to using computers. Student experience in using computer software packages is fairly varied with large numbers being familiar with word processing (92%), database (61%) and email (69%). Though 82% have regular access to computers outside the university, only 53% have regular access to the Internet, while 78% are familiar with using this medium. When asked about their interest in receiving some, or any of their coursework via computers, 81% are either very interested in doing so, or didn’t mind if this development takes place.

Given that this is the current status of student access and usage, the VRC site will remain low technology for the foreseeable future; not requiring students to have state of the art hardware, and avoiding the need for them to download software from the web. In an effort to help students become more computer literate, they were introduced to the computer laboratories, logging on procedures, email access and the VRC site in the first week of semester 1. Difficulties with name and password access are still current, but with perseverance and patience, such problems are gradually being overcome. Students are encouraged to seek assistance whenever it is required, and tutorials have also been offered to assist the less confident students. The non-threatening nature of the Discussion
Forum will also help students develop the specialist skills necessary for using the computer and Internet effectively. Student usage of the site will continue to be monitored throughout the next 12 months and beyond.

Free staff from being seen solely as information providers

At present, the VRC is nothing out of the ordinary, though its potential is great. Though commencing its life in a fairly traditional manner, it is anticipated that the site will evolve away from a didactic and content driven approach. Much of the content material for semester one is now available on the web giving students access to this information prior to attending lectures. Thus teaching staff now have the opportunity to use their valuable face-to-face time in a different manner. For example, rather than using this time to present new material, these sessions can be used to explore the main concepts in more depth through student discussion, debate, and role play. The extent to which such teaching sessions change, will depend upon the enthusiasm and interest of the individual lecturer, the amount of support and encouragement they receive, and how students respond and adapt to such changes.

With the addition of links from the core content material contained in the VRC, to other specialist resources available on the web, core resources can be augmented, and enable students to explore the material in more depth. Lecturers can use this as an opportunity to investigate the validity and authority of the scientific information currently available on the web, whilst encouraging students to critically analyse the information sources they consult.

Times of cultural change, as represented by the emergence of sites such as the VRC, are not always easy, or seen by staff as rewarding and challenging. Many see such change as not only time-consuming but of little visible benefit to student learning. Certainly if teaching and learning practices do not change concurrently, there will be little improvement in learning outcomes. Therefore it is essential that both academic development and the establishment of student support systems develop hand in glove with the evolution of the web site.

A site encouraging collaborative learning, individual challenge and stimulation

UWS Nepean draws the majority of its students (67%) from the Greater West region of Sydney, and though the majority of students (59%) attend university full-time, a significant number (41%) of part-time students are enrolled. All discipline areas have students for whom English is not their first language, but science (56%) is one of the disciplines most affected. Such characteristics affect the types of resources developed, the way concepts are expressed, the manner in which face-to-face sessions are conducted, and the activities that are advanced to enable students to interact with the material. However, working and learning collaboratively are essential skills in today’s workplace, irrespective of the student’s background, and as such should be encouraged, valued and nurtured. By developing both challenging and stimulating material for consideration in the Discussion Forum, and assessment tasks that require students learn in teams, both in class time and on-line, such skills can be practiced in a congenial environment.

The development of the skills of independent learning and individual responsibility for learning

An attitude that is commonly encountered amongst students is that the content covered in lectures is the extent of what should be learnt; it can come somewhat of a shock to learn that more is expected. The VRC will enable students to access material to the minimum depth and beyond, depending upon individual interest and motivation.
It is also often the case that students will only treat learning seriously when it is assessed. If we require students to value the learning outcomes as intended, we must develop assessment tasks in which the attainment of such outcomes is fostered and rewarded. Again, over the coming months, lecturers will be assisted in developing suitable materials and activities, and at the same time, students will be helped develop the skills to enable them to tackle the required tasks.

Students who use the Discussion Forum to raise issues of concern in their learning, will find it helpful in developing their questioning and problem solving skills, assisting them to take more responsibility for their own learning.

A ‘Community of Learning’

From the beginning, both staff and students have been encouraged to view the VRC site as their own, its evolution to a form that is beneficial to all being the aim of the early years. Thus each participant has a common purpose, and the barriers between lecturer and student should weaken. The Discussion Forum will also encourage the further development of a ‘community of learning’ by giving all staff and students a voice. Such a community should thrive through student and staff participation in well chosen discussion topics and structured stimulus material; in an environment where thoughtful and considerate discourse is insisted upon, as are the norms of open-mindedness and civility.

Conclusion

Now that the site exists in a physical form, teaching staff are beginning to see possibilities, and offer suggestions that will help students with their learning. Self-assessment questions, tasks that require students to interact with the material and each other, and simulations that enhance laboratory learning, are all currently being developed. Staff are also actively exploring the Internet for sites of excellence that can be included as links to their material. There are also signs that the emphasis on a content driven curriculum is weakening.

The Science Virtual Resource Centre is not meant to replace existing resources or teaching practice, rather it is seen as an additional resource that enables students to access and interact with materials in a manner that may better suit their learning needs and learning styles. The site has provided the impetus for change, and as a dynamic site, it itself will alter to suit the changing needs of staff and students. Reconstruction of the VRC will not only occur from the top down, both students and staff will be asked to participate in its evolution, providing a truly flexible resource, and the beginnings of a ‘community of learning’.

Reference

It’s not about putting lecture notes on the web!

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Introduction

The use of the World Wide Web as part of flexible learning delivery is now well entrenched. To many people, it seems, flexible learning is synonymous with the use of information technology. Flexible learning is, of course, a much broader concept. In this article I describe examples of the use of web technology in teaching of undergraduate and postgraduate subjects. The examples chosen show that there are a number of exciting options for using the web that have little to do with transmission of content and much more to do with interactions amongst students, teachers and the body of knowledge.

The following table is a suggested hierarchy of web-based activities and indicates where examples have been described in this paper.

<table>
<thead>
<tr>
<th>Level</th>
<th>Classification of Web-based Activity</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>Student Designed and Controlled Activities</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Teacher Structured Asynchronous Activities</td>
<td>✔</td>
</tr>
<tr>
<td></td>
<td>Role Plays and Debates</td>
<td>✔</td>
</tr>
<tr>
<td></td>
<td>On-line Learning Dialogues</td>
<td>✔</td>
</tr>
<tr>
<td>4</td>
<td>Informal Interactions with Class Members</td>
<td>✔</td>
</tr>
<tr>
<td></td>
<td>Talk with peers and/or teachers (typically this might take the form of a “café” chat area within their learning system)</td>
<td>✔</td>
</tr>
<tr>
<td></td>
<td>Informal Questions and Answers On-line</td>
<td>✔</td>
</tr>
<tr>
<td>3</td>
<td>Information Retrieval/Analysis</td>
<td>✔</td>
</tr>
<tr>
<td>2</td>
<td>System Interaction Activities</td>
<td>✔</td>
</tr>
<tr>
<td></td>
<td>Interactive Web-based Multimedia Packages</td>
<td>✔</td>
</tr>
<tr>
<td></td>
<td>Self Monitoring of Progress²</td>
<td>✔</td>
</tr>
<tr>
<td></td>
<td>On-line Testing (multiple choice etc.)</td>
<td>✔</td>
</tr>
<tr>
<td>1</td>
<td>Downloadable Content</td>
<td>✔</td>
</tr>
<tr>
<td></td>
<td>Multimedia (animation/audio/image)</td>
<td>✔</td>
</tr>
<tr>
<td></td>
<td>Static Content and Hypertext Documents</td>
<td>✔</td>
</tr>
</tbody>
</table>

Level 1(a): Static content provided on-line

A strategic initiative by the University into flexible learning prompted the development of a virtual Physics Learning Centre (vPLC) to provide some of the same support functions of the “real” PLC (primarily one-to-one tuition and up-to-date information). Worked answers to tutorial and past exam problems were provided in digital form (by scanning). The problems were selected in response to student email requests or after enquiries in the PLC. An analysis of usage of the virtual centre indicated that these hints and solutions were by far the most sought after aspects of the site. Level 2 activities including on-line multiple choice diagnostic tests (see below) were utilised to a much lesser extent. On-line discussions of open questions (level 5) from the tutorial book were hardly visited at all and not utilised.
Students perceived that having 24-hour access to materials was of great benefit. The same materials could now be printed in a booklet and 24-hour access would still be guaranteed! Indeed the web server statistics shown in Figure 1 paint a somewhat grim picture for student study habits in the lead up to the final examination. Each vertical bar corresponds to server “hits” each day. The final day of semester and the two first year physics examinations (life sciences and physical sciences/engineering) are evident in the graph.

![Figure 1. Daily server hits for the period including the last week of semester and examinations in first year physics subjects](image)

**Levels 1(b) and 2: Multimedia content and packages**

One circumstance in which web delivery of static content can be considered more appropriate is where the content itself is genuinely digital in nature, and especially when linked with other forms of communication amongst class members. The versatility of the WWW for delivery of graphics, video and audio, as well as electronic attachments is now well understood and makes it possible to design content rich learning activities for on-line delivery. Of course, much can also be burnt onto CD-ROM and posted out.

The magnetic properties of materials are an example of macroscopic-microscopic duality. The use of the computer simulation *MagSim* to help explain magnetic behaviour by *simultaneous* display of microscopic and macroscopic realms has been an ongoing development.\(^1,4,5\) The package was designed to simulate experiments by having options and adjustable parameters. On-line processing of this data returns an embedded *QuickTime* movie *on the fly* (see Figure 2). Regrettably, fully interactive use of the package has proved to be too demanding of network and server hardware so a pre-packaged (CD-ROM compatible!) version is used as part of a revision class.
Level 2: On-line diagnostic tests

For a number of years all new students who undertake first year physics at UTS have been given readiness tests. The tests cover Science, Mathematics and Physics concepts with multiple choice questions. This strategy was ported to the web and was promoted within the virtual centre early in the semester. The tests are a good example of formative assessment and students are encouraged to re-sit the tests later on.

Level 3: Bringing information skills into the frame

A guest book web server application was used to encourage students to develop their skills in information retrieval and critique of web-based information. As part of the learning activity, students are introduced to search engines and how to use them and then asked to go out and find a URL and to explain the relevance of their finding to the subject matter. A standardised format for the contributions was possible within the server software. Naturally, any system that documents hyperlinks and allows student comments could be used. Some examples include:

- **NOVACAP’s Technical Brochure: Ferroelectric Ceramics** has been contributed by Jenni because it provides a good summary of ferroelectric ceramic characteristics and takes the subject just a bit further than what’s done in class. It also concentrates on barium titanate, which is of interest at the moment, but discusses the advantages of using other ferroelectric ceramics instead.

- **How Things Work: Magnetically Levitated Trains** has been contributed by Iain because it helps to summarise some of the magnetic section of the subject.

Level 5(a): Open questions and asynchronous discussion systems

A strategy has been developed to engage students in on-line dialogues with each other, with the teacher, and importantly, internally with themselves. The benefit of this semi-formalised “thinking aloud” has been recognised as an important attribute of computer mediated discussion. The asynchronous discussion format provides a flexible and interactive vehicle for this thinking and dialogue to take place.
The important elements of the strategy are:

- open questions as the stimulus (room for interpretation in question and answer);
- exploration of the question can usually take place at several levels;
- each question (module) starts a fresh newsgroup;
- questions are set as prework for next class (often revision of earlier studies);
- virtual tuition (comments/arguments) from peers or teacher;
- self review later in semester; and
- participation in the discussions forms a small part of the assessment.

Newsgroup software (\textit{HyperNews}) which supports multiple threading and indentation of responses was used for its simplicity and robustness. The software supports a variety of modes for the attachment of messages including a “smart text” as well as HTML and the embedding of entire URLs.

Figure 3 shows schematically the life cycle of a module down the right hand side with the key teacher inputs on the left. A module will remain “active” for at least 4 weeks to allow stragglers to complete (commence) the module. The input from the teacher feeds in, where necessary, to ensure discussion proceeds productively. Critical stages have been found to be just after the module stimulus is posted, and at the end, when contributions from students are synthesised into a summary record. To encourage student involvement, the students’ participation in modules is assessed.

![Figure 3. Schematic diagram showing the timeline of a learning dialogues module. The involvement of the teacher at key points in the process is shown as inputs from the left.](image)

**Level 5(b): Role play using asynchronous discussion**

Dr Rob McLaughlan, National Centre for Groundwater Management at UTS has had considerable success in his teaching in environmental decision making by incorporating an on-line role play as a major component of the student activity in a subject in Environmental Management.

The objectives of the simulation are to identify political, social, economic and scientific dimensions to decision making, to identify responsibilities and responses to environmental issues and for the students to develop their communication, negotiation and decision making skills.

The activity was structured with four weeks of preparation (orientation to web-based teaching tools etc.), two weeks of on-line persona development (Figure 4), nine weeks of the live role play followed by a two-week de-briefing phase at the end.
Summary

In the examples one can see an increasing sophistication in the way the web-based tools can be used to encourage discussion and dialogue amongst students. Far from being definitive, the hierarchy presented gives an indication of the range of options for flexible learning using the web, especially learning environment packages.

In all of the higher level activities, the teacher plays a crucial and non-traditional role. They are responsible for the design of the activity, the “nuts and bolts” of producing it on-line, and of monitoring and facilitating the progress of students. They are, as such, still teacher controlled learning experiences.

The suggested top-level activity (student designed) could potentially provide powerful learning opportunities but might not be appropriate in some circumstances. For instance, the mechanics of developing the activity might distract from the real message.

Software packages that are better able to support student-constructed pathways, and allow greater student autonomy, as well as supporting more natural communication (i.e. non-typing) are still around the technological corner. That said, there is still a great deal that can be done with existing learning systems that isn’t just putting lecture notes on the web!

References

5 Green, D. (1997) MagSim and Beyond: web based interactive multimedia projects, Presented at the 3rd OzCUPE Conference, Queensland University of Technology.
The School of Applied Sciences at the Gippsland Campus of Monash University has had extensive experience in the teaching of cell biology, physiology, microbiology and biochemistry programs by distance education. Laboratory requirements in these subjects are met by off-campus students using many different approaches, including residential schools, computer simulations, independent experimentation and home laboratory kits.

History

As part of the Gippsland Institute of Advanced Education (GIAE), the School of Applied Sciences served predominantly Gippsland and Melbourne metropolitan-based students studying for diplomas and degrees in the applied sciences. Courses were first made available by distance education to service students who were employed in industries in the La Trobe Valley and therefore unable to attend traditional classes. While the basis of the theory course was delivered in print form, supplementary tutorials and the laboratory classes were held on weekends. Students attended what came to be known as “Weekend Schools” three to four times per semester. These distance education courses became attractive to people further afield and gradually the geographical range of the student base expanded.

In the late 1980’s it became clear that the weekend school model was becoming unsuitable for many of the students, since the costs associated with travel to the campus (from places such as WA, NT and Tasmania) were considerable. It was decided to create a first year program which involved no on-campus attendance requirement, followed by second and third level programs where attendance requirements were blocked into concentrated residential programs.

The programs

As the School of Applied Sciences, we have a commitment to provide graduates with extensive training in practical skills, therefore all courses emphasise “hands on” practical work. Staff felt that this training is essential right from the start of the course, as it has a dual role: allowing students to develop skills and competencies; and encouraging them to apply their theoretical knowledge to a practical situation. The latter enhances their understanding and facilitates learning. There was a strong commitment to retain this practical emphasis in designing the new distance education programs. In upper level subjects, the (appropriate) use of computer simulations reduced the number of hours which students had to spend in classes at the University campus. This made it easier to block the remaining exercises into concentrated residential schools. At first level, the development of laboratory kits and home experiments enabled students to complete practical exercises without any travel requirement.

Computer simulations

Computer simulations are used to supplement the laboratory programs. They have been found particularly useful in areas where collecting ‘real’ data is impractical. For example, a natural selection simulation is used in first level Biology to explore one of the mechanisms of evolution, while a peptide sequencing simulation exposes second level Biochemistry students to experimental work that
would otherwise be outside the scope of the undergraduate laboratory. In our experience, however, computer simulations are useful only when students have some practical and theoretical competence in the area being simulated. If this is missing, it is difficult for students to follow the simulation and gain a true appreciation for what it shows – the danger is that simulations can be treated as sophisticated computer games. When used in this way, simulations may well be intellectually stimulating, but have little value in terms of training students in experimental strategy.

Residential schools
In residential schools, second and third level students complete a traditional laboratory program in a restricted time frame (3 – 6 days, depending on the subject). Because there are no timetabling restrictions (unlike on-campus laboratory classes) it is possible to start a second experiment before completing the first. This enables compression of the time taken for all exercises to be completed and, importantly, it mimics the dovetailing of activities that naturally occurs in the workplace.

Laboratory kits
Laboratory kits for the first year biology subjects, Cell Biology and Biology of Mammalian Systems, were developed by the biology teaching staff. Each staff member was asked to prepare one or two laboratory exercises addressing a particular aspect of the course. Once they were prepared, the laboratory exercises were trialled by an “intelligent non-biologist” (a Chemistry graduate) who provided detailed feedback about any procedures she felt were unclear. The laboratory guide was modified accordingly before being sent out to the first group of Distance Education (DE) students. This preparation phase was vital and a measure of its success is the fact that only minor modifications have been required since. Once the DE laboratory course was finalised, a similar on-campus laboratory program was developed. There are subtle differences between the on-campus and DE laboratory programs, primarily reflecting equipment availability, but the students are exposed to the same concepts and develop the same skills.

The Cell Biology laboratory program consists of five practical exercises, encompassing histology, enzyme activity, membrane permeability, photosynthesis and the modelling of DNA replication and protein synthesis. The Mammalian Biology laboratory program also consists of five practical exercises, encompassing salivary secretion, a rat dissection, exercise physiology, the nervous system and natural selection. Some laboratories are larger than others so contribute a larger percentage of the practical marks.

Making it work
One of the most difficult things for isolated students to overcome is their lack of confidence. Therefore the early experiments must work and the subject adviser must be contactable, understanding and able to help when problems arise. For example, the second exercise in Cell Biology requires a lot of preparation. Many students contact the subject adviser in relation to this exercise and it is essential that they receive a rapid and useful response. The experiment itself, however, is very robust and students inevitably achieve good results, despite their lack of experience. Having leapt this hurdle successfully, our experience is that students are prepared to tackle subsequent experiments, some of which are more difficult, with significantly less assistance.

The safety of the students, and of couriers responsible for delivering kits to students, must be considered. The regulations for transport of dangerous or hazardous goods dictate appropriate precautions. We generally use road transport to deliver kits because air transport regulations are very restrictive. We are unable to send complete kits overseas.

Kit components must be securely packed and clearly labelled especially when similar materials are required for different experiments. Comprehensive safety information is provided both in the kits
and in the laboratory notes. We have not been made aware of any safety problems arising during the past decade.

**How successful is the kit option?**

Laboratory reports for both DE and on-campus students are assessed by the same staff member and according to the same criteria. The performance of the DE cohort is at least as good as that of the on-campus students. This may reflect a whole range of motivational and other factors. The DE students obtain sensible experimental results, which they are able to interpret and explain.

Optional weekend schools are available to students of Mammalian Biology. It is interesting to note that the majority of students do not take up this option. Those who do are difficult to categorise. Some are “new starters” who have not previously undertaken tertiary study. Others lack confidence, perhaps because they have limited prior knowledge in the subject area; some just need to be reassured that they are doing the “right” thing. Others seem to enjoy the social contact and do not live at a prohibitive distance from the Gippsland campus.

**Parity between on-campus and kit-based DE programs**

The evolution of the first level course has meant that the on-campus laboratory program reflects the DE laboratory program, rather than the reverse. This does not mean that the laboratory programs are reduced in any way, it is just that we are careful that the experiments we have chosen to illustrate aspects of the theory course are achievable by students working at home using kits.

Although DE and on-campus students carry out the same experiments, the time commitment required by DE students is often greater, since they have to prepare their own materials, such as buffers, enzyme preparations, chromatography solvents etc. In some instances, they may also be required to source and purchase experimental materials. Chicken hearts (for enzyme extraction), acetone and unleaded petrol (for chromatography solvent) are some examples. The DE students are prepared to do this ‘extra’ work as they acknowledge the advantages of reduced travel and increased flexibility.

There is no distinction between on-campus and DE students in terms of grades received for practical work in the first year or in their laboratory performance in subsequent years. This would indicate that the outcomes of the programs are comparable. Student feedback shows that the DE students, themselves, do not view their experiences using the kits as inferior.

**Conclusion**

Kit-based laboratory programs have proved to be a viable and valuable option for first level students. Their flexibility enables distant students to choose when and where they complete the laboratory components of their course. These programs have been shown to foster the development of practical skills and competencies which are required in higher level studies in the biological sciences.
The University of Queensland is unique in providing Australia’s only specialist entomology teaching program. Undergraduate and postgraduate coursework degrees as well as research higher degrees are offered. Our historically low enrolment numbers in coursework subjects have allowed us to offer highest quality education but this practice is not sustainable given current funding restraints. On 1 January 1999, the two existing Departments of Entomology and Zoology were amalgamated. The Faculty and new Department of Zoology and Entomology have a verbal and written commitment to maintaining the national role and international reputation of Entomology at UQ. However a consequence of the amalgamation is that where Zoology and Entomology used to each have a set of discipline-specific subjects, the Faculty now requires one composite set of subjects. We are being forced to dramatically cut the number of Entomology subjects we can offer and are already struggling to maintain what we consider to be the core undergraduate subjects for good training of Australia’s future entomologists.

To overcome these problems we are developing a flexibly delivered curriculum in Entomology at the undergraduate and coursework postgraduate levels. To date ‘flexibly delivered’ has equated fairly loosely with remote or external. We have been offering a few subjects to ‘off-campus’ students since the beginning of 1998. Included in these have been two subjects offered through Open Learning Australia. This year we are working to improve the subjects we already offer and develop additional ones. By the end of 2000 we will have our second year and core third year subjects of our curriculum available for non-classroom based enrolment.

Nature of delivery

The flexible delivery teaching program is web-based at present and is supported by a variety of software presented on CD-ROM. Our first step towards flexible delivery was to develop detailed lecture outlines in HTML for WWW presentation. Ideas, concepts and terms are hyperlinked as an aid to learning so that students may move between related subjects to find more detail about topics of interest. In this way students are encouraged to explore other entomology subjects, even ones in which they are not enrolled, and to begin to appreciate how material presented in different subjects is interrelated. The web notes are heavily illustrated with line drawings and photographs. Most photographs are stored on CD-ROM and the images linked to the notes. Videos will be incorporated during this year. The Department has employed a graphic artist and a web page developer for two years. They have been responsible for scanning images, drawing and obtaining photographs. They have also been responsible for ensuring copyright is not infringed whenever the material needed is not our property. For some subjects the lecture notes serve instead of a textbook if a suitable one is not available. For other subjects the notes have frequent references to the prescribed textbook.

The development of practical modules is a high priority for this year. Some of our subjects are orientated towards identification and for these we are using the interactive identification software package called *LucID Professional*. This package was developed through the CAL unit of the CRC for Tropical Pest Management (CTPM) in conjunction with staff of Entomology at UQ. With the demise of the CTPM in 1998 a Category 2 Centre has been established in the Department. This has taken over the role of the CAL unit of the CTPM and is called the Centre for Pest Information Technology and Transfer (CPITT). Software packages developed by CTPM/CPITT in addition to *LucID* include:
These packages have been developed for a variety of end-users but all are adaptable for use as teaching tools. We anticipate incorporating their use into practical modules for teaching economic entomology, urban insects and taxonomy-centred subjects.

BioED

Last year the Department of Entomology was successful in obtaining a CUTSD grant for a project called “BioED: Biodiversity and education in an interactive, multimedia environment”. This project is based on the LucID program. The methods used for identifying organisms in the biological sciences have not changed during the past 200 years. The traditional method of identifying animals and plants relies upon printed “taxonomic keys” which consist of a sequentially numbered series of paired, contrasting statements which lead to an organism’s name. This traditional method is time consuming, tedious and replete with problems. University students find the process dull and sometimes irrelevant to their personal educational goals. Our ability to teach students about biological classification and biodiversity has been encumbered by these outmoded educational tools. The LucID platform is revolutionary in that the system is computer based and any character can be selected from the main menu without proceeding through a mandatory sequence of couplets. All required information on the anatomy of organisms is built into the LucID system and the user may view drawings or photographs of all of the possible states for that character. When a selection is made, the organisms which do not possess that state are eliminated from the pool of possible names. With conventional, paper-based dichotomous keys, the user must proceed through the key in the specified way. If parts, structures or character states are missing, the user cannot proceed further. If character states are poorly defined or misinterpreted, then the user makes a mistake in identification. In sharp contrast, LucID operates as a user-friendly problem-solving exercise. Characters which are missing do not pose an insurmountable problem. Students can work at their own pace, pursue their own interests in particular groups and, through a series of set exercises, develop a proficiency of identification at several levels. After discovering the identity of a taxon, the user can then access all manner of relevant biological information included by the key builder.

BioED consists of 14 projects and will include taxonomic information on major groups of organisms (bacteria, Protozoa, arthropods, plants and frogs). BioED will be developed for specified taxa by specialists in three participating universities (UQ, The University of Sydney and The University of Adelaide) and will, we believe, reform teaching methodology in an important area of the biological sciences. The Project has three goals: 1. develop new identification tools (LucID keys) for CD-ROM and the Internet to enable us to teach organismal biology subjects more effectively and provide information which relies upon the accurate identification of organisms; 2. restructure and alter the way we teach subjects which rely heavily upon the identification and classification of organisms; and 3. stimulate a chain-reaction in other tertiary institutions within Australia with new and additional taxonomic keys which are easier to use.

Audience

A flexibly delivered teaching program has several advantages for Entomology. First, it offers increased choice to external and internal Australian students. At present we are in the process of persuading our administration to change undergraduate rules to allow us to offer resource-based rather than classroom-based subjects to UQ internal students. Students wishing to take individual entomology subjects for vocational or general interest reasons should also be advantaged by the move
to be less bound to university campuses. By removing the geographic restrictions of campus-based subjects we are hopeful of increasing our total enrolment in undergraduate subjects. An added advantage is the removal of timetabling restrictions on student enrolments, allowing students to choose their own schedules and even enrolment times.

One of our longer term objectives is to develop a national curriculum in entomology and to foster participation from researchers or teachers in other institutions. Expertise of academics and other professionals throughout Australia could be employed to develop parts of subjects and supervise specialist components. We would then encourage teachers of undergraduate Insect Science subjects throughout Australia to utilise the Entomology program. Thus students would have access to a standardised, high quality curriculum while maintaining valuable face-to-face contact with local teachers. Entomology staff could maintain communication with staff and students in other institutions by email, videoconferencing, and/or electronic discussion groups.

For international students without a satisfactory background in entomology, the flexible delivery program has special advantages. At present many of these students are required to complete a coursework Postgraduate Diploma before gaining admission to a research higher degree. The advantages of enabling these students to complete this preliminary course in their home countries are obvious: huge monetary savings for the students and for funding bodies such as AusAID; one year less away from families; familiar surroundings in which to adjust to the standards and expectations of postgraduate work at the UQ or other Australian institutions. Because the Postgraduate Diploma is not a research higher degree, students are not eligible to apply for scholarships. For privately funded students this offers a major disincentive to enrol for a higher degree at UQ. For international students wanting a higher degree from an overseas university, but not wanting to undertake a research degree, being able to complete a coursework degree at home has similar advantages.

Conclusion

By means of the flexible delivery teaching program at UQ we intend to maintain a comprehensive Entomology curriculum despite removal of departmental status for the Entomology program. By this means we also hope to overcome the danger of losing important subjects from the curriculum because class sizes are not large enough for those who count dollars. At the same time we will expand the boundaries of entomological training by providing access to Australia-wide and international audiences who would otherwise be required to attend classes at the St Lucia campus of The University of Queensland.
Introduction

Biochemistry is a very broad and complex discipline, knowledge of which requires the ability to integrate a wide range of concepts. It is a challenge to teach students, especially in large classes, how to acquire this skill. This can be partly overcome using Computer Aided Programs which provide a highly flexible way to deliver difficult material and enable students to learn at their own pace, in their own time.

We have therefore developed a CD-ROM entitled Biochemistry – A Metabolic Challenge for teaching the principles of metabolism to a variety of university undergraduates including science, biomedical and medical students.

The package forms the basis of a non-traditional and very flexible approach to the acquisition and development of learning skills; it is used as the focus for both Problem-Based Learning exercises and case study related Self-Directed Learning, as well as being a resource for information, revision and self assessment. In a teaching sense, the package is utilised in different ways depending on the background knowledge of the students, the objectives of the particular course and the size of the class.

Description of the CD-ROM

The CD-ROM contains two interactive problem solving exercises, namely “The Great Metabolic Race” and the “After Race Banquet”.

These exercises relate specifically to the catabolic metabolism associated with long distance running and the anabolic metabolism associated with the recovery phase. They test the students’ ability to integrate and understand concepts and pathways that are often learned in isolation. The exercises involve true/false questions, multiple choice questions, ‘click and drag’ questions and answers and calculations, the results of which are scored by the computer.

A series of quite extensive self-paced tutorials on various aspects of metabolism accompany and are linked to these exercises. The tutorials are also highly interactive, using animated demonstrations, ‘click and drag’ reaction sequences, ‘click and drag’ question and answers and multiple choice extension questions. The tutorials serve as an information resource and the information within them can be readily accessed through a comprehensive index of topics, even while undertaking the exercises.

For example, in one such question screen (Figure 1a), a student who is unsure about the pathways used by the muscle to produce acetyl-CoA for energy generation can obtain assistance from the tutorials using the Index link.

In this example, the student can click on “Muscle” in the Index, followed by “Pathways Utilised by” to find the required information as shown in Figure 1b. In this manner, students must think logically about how to find the information rather than being led directly to it using hyperlinks.
Self-Directed Learning

In order to stimulate and challenge students we have adopted a much more self-directed learning (SDL) approach whereby students are expected to analyse problems, locate relevant source material and develop habits of independent study. Students receive a reduced core of basic lectures, supplemented with SDL tasks that are largely case study based.

Case studies are conducted in small tutorial groups (~10 students) which meet for approximately 3 hours. Students are expected to prepare for the tutorial in their own time and are responsible for the running of the tutorial. The tutors act merely as facilitators.

The case study on “The Metabolism of Alcohol” analyses the disturbance of liver metabolism due to the over-consumption of alcohol. Students should first review all the major metabolic pathways normally active in liver. Figure 2 identifies each of these pathways and has links to the tutorials (as shown by circled numbers) and to multiple choice questions with feedback answers.

As hinted at in Figure 2, the NAD⁺/NADH ratio is sensitive to alcohol and students need to explore why this is so, and identify which of the pathways will be affected by changes in this ratio.
Only then can students begin to deduce the impact of excess alcohol on the liver. Computer programs are ideal for this type of investigation because they readily enable the visualisation of pathways and the relationship between them.

**Figure 2. Major metabolic pathways occurring in liver**

**Evaluation of the CD-ROM’s educational value**

Response to a survey conducted with science students (250) and medical students (160) indicated that 90% of the students gave a score of 4/5 or above in terms of improving their understanding of the subject. The same percentage of students preferred this Problem-Based Learning approach.

When an independent review of the package was conducted by Dr. L. Brown (University of Western Sydney), the following comments were made: “I believe the package to be an excellent aid to studying metabolism. It gives a visual dimension to what can be difficult conceptual ideas. … In fact, I liked it so much I have ordered it myself” (see Note below).

A recent survey conducted with medical students who participated in the SDL sessions indicated that this mode of learning is preferable even though it is generally at least 2–3 times more time consuming for students. SDL is also more time consuming for staff as follow-up tutorials are conducted in small groups requiring several staff members to be conversant with the topics.

**Access to the computer programs**

The package will be linked to a WWW site on Biochemistry, developed by A/P M. King, Terre Haute Centre for Medical Education, Indiana State University (http://web.indstate.edu:80/thcme/mwking/lectures.html). The package is also available on the Monash University Intranet.

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**Note**

*Biochemistry – A Metabolic Challenge* was previously known as *Interactive Biochemistry – Metabolism* and the review of the software, conducted by Dr. L. Brown, was published in UniServe Science News, Vol. 12, March 1999, p19.