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From the Director

In my column in the last issue, in order to try to provoke some feedback from our readers, I asked the question "Is anybody out there?" At the same time, we surveyed directly by email our departmental contacts and on-line discussion groups. We didn't get an overwhelming response, but we got some — about 15% of those we asked. To those of you who replied let me say thank you. To those of you who didn't get round to it, please feel free to do so now. We really would like to know what as many people as possible think about what we are doing.

As I've explained before, we need this information to help us get funding to continue past what CUTSD considers to be our use-by date (early next year). So it was gratifying that the vast majority of your responses were supportive. You obviously like the reviews of software packages we commission and publish. It seems you prefer to read a fellow academic's opinion rather than a spiel from the author or publisher. You liked our workshops too, again mainly for the opportunity to get together with others doing much the same kind of teaching.

Our newsletters are managing to get around most of your departments (though clearly not all) and are seen as an easy way to keep up to date with what is happening in the teaching area of your own sciences. You thought our electronic discussion groups were a bit moribund for a while, but seem to be picking up a bit now.

We also had a couple of responses from overseas. Interestingly both found it ironical, that while their leaders are talking about starting up something along the lines of our clearinghouse, our government will no longer support us and we may have to close.

You also pointed out some things we haven't done well — mainly in the area of communication. Firstly we are clearly not reaching everyone teaching sciences in our universities by a long way. (We knew that: we still keep meeting, distressingly regularly, science academics who have never heard of us.)

We hope that we've started to remedy that.

We've sent out QuicKards so far to 559 physicists and 648 chemists. Those numbers represent, to the very best of our knowledge, all physics and chemistry academics in the country. The rest of you, please hang on. The biochemistry QuicKard is under way, and the biology, psychology and earth sciences ones shouldn't be too far off.

Secondly, we've failed to respond to some of you in the past. There were reasons for this, including the fact that we changed staff early this year, but we'll certainly make every effort to mend that.

There were other interesting items we got from our survey. Considerably fewer of you have visited our website than have read our newsletters. And even fewer have used the searchable database which is on our website. I find that an interesting statistic. It could of course mean that our website isn't particularly good, but I suspect it means that many of you (like me) are not, as yet, great web users. A lot of you commented that you just did not have enough time to use the Web much. That should be borne in mind when we (or anyone else) are thinking about the future of organizations like UniServe Science.

I think this response said it all:

"I would be sorry to see this service disappear, especially when there is increasing pressure to use Computer Assisted Learning due to budget constraints. When and if we get enough money to spend up on computers (and space to put them — or all our students have access to the Web), it will be handy to have the information and expertise at UniServe Science to help decide how to implement CAL."

Anyhow, our funding is still completely uncertain. We'll certainly let you know if it gets any better. In the meantime we intend to carry on exactly as though we will survive. We're already planning our next workshop (see page 8). See you there.

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Communicating to Teach and Communicating to Learn: Using the World Wide Web for Science Teaching and Learning

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Much effort is being expended on exploring the use of the WWW for teaching and learning. One of the reasons for this is that the WWW presents unparalleled opportunities for modes of communication with which new and different teaching and learning techniques can develop. Since the heart of teaching and learning is communication, the WWW represents fertile ground for educational development.

In these early stages of development, what are some broad categories of web usage for science education? Let's consider five categories in terms of the technology they require and the kinds of communication they foster.



1. Basic HTML — Information Delivery

A basic HTML (hypertext markup language) document can deliver a great deal of information including text, images, movies, and sounds. Such documents are good for one-way communication, with information passing from the teacher to the student(s). A WWW browser can access such documents from the simplest storage medium, such as a floppy disk that the student picks up in a faculty office, as well as from a WWW server.

The vast majority of web-based education-related material falls into this "information delivery" category. Examples are standard syllabi, lecture notes, course calendars, etc. These materials, by their very nature, provide little interactivity. They do not permit communication from student to faculty, but they do provide 24 hours a day access to information — as the students need it.



2. Basic HTML + "MailTo"

A small step beyond the most basic HTML is a document with a "MailTo" hyperlink. A click on a hypertext link brings up an email

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message composition window, allowing the student to communicate with the faculty member via electronic mail. "Smart syllabi" which give students the ability to email their instructors at the click of a mouse are examples.

Another small step in HTML sophistication is an HTML document that contains "forms." Students can interact with such documents by typing into text boxes, clicking buttons and making selections. The students' responses are submitted to the instructor as an email message. This is a very powerful capability: students can interact with an HTML document and, *by clicking a button in the document being displayed*, send their responses to their instructor via email. This requires no interaction with an email application, and no need for a WWW server running a common gateway interface ("cgi") application. Students do not even need an email account. This is a very useful technique for establishing two-way communication between faculty and students without involving a WWW server.



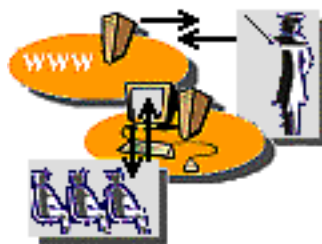
3. Web pages including Java/JavaScript, No WWW server

A scenario that may play an increasingly important role, particularly in the use of the WWW for science education, involves a student computer running a WWW browser, with a look and feel of an interactive application. The interactivity is built into the document itself via JavaScript and/or Java applets. The natural uses of such a scheme include WWW-based self-assessment activities for the student, drill materials, and progress-check quizzes. The WWW technology is an ideal way to offer platform-independent, stand-alone mini-applications such as student problem-solving exercises and visualization and simulation activities. Although a convenient mode of delivering such materials is via a WWW server, this is certainly not required. The document itself contains the feedback data and logic. Using the browser application to leverage the logic contained in the document makes use of the innovative features of the Java technology. Of course, a natural and likely extension to this scenario is one in which a summary of the student's session is assembled by the browser and submitted to a WWW server for the faculty

member's use for diagnostic, evaluation, or assessment purposes.

With the recent rapid increase in capabilities afforded by JavaScript and Java applets, the possibilities for effective usage of this "client-side" (or "student-side") interactivity are exploding. Many programs making use of heavy client-side interactivity are currently under development, such as for example the Johns Hopkins Virtual Engineering/Science Laboratory Course¹.

Scores of Java applets being developed are excellent building blocks with which to construct interactive student-centered WWW activities. The Davidson College physics applets known as "physlets"² are excellent examples; these are being used regularly in WWW-based activities at many institutions in the US.



4. WWW Server

When the instructional materials reside on a WWW server, possibilities for increasing interactivity and two-way communication unfold rapidly. In educational settings an institutional WWW server is often available to the faculty. However, an individual department or research group may also maintain its own WWW server, on which educational materials may reside.

Available from a WWW server, curricular materials can provide a high degree of interactivity that is accomplished via communication between the student computer and the WWW server. This means that the HTML documents themselves do not need to be particularly sophisticated, since the "intelligence" can be provided via processing done on the WWW server.

Two remarkably different science education examples which use, student computer - WWW server interaction, and show the gamut of uses of the technology are the "Virtual Prof" and "Cockpit Physics" sites. The Virtual Prof³ site is essentially a web-based service for students and faculty who wish to have help preparing for and writing physics examinations. The Cockpit Physics⁴ site is the home of 32 completely web-based lessons for the first semester of

introductory physics. Each lesson consists of exploration, theory, and application sections in which students work through a variety of activities, entering answers to free-form questions and responding to multiple choice progress check quizzes.



5. WWW Server, Web pages with JavaScript/Java

By far the highest degree of interactivity and communication can be accomplished by combining the use of a WWW server and "intelligent" HTML documents which include JavaScript or Java applets. It is in this realm that most of the "cutting edge" WWW-based educational developments are now occurring. With both WWW server access and HTML documents that carry their own "intelligence," all the lines of communication are open, and in a variety of ways.

What is striking about the developments in science education in this arena to date is the diversity of approaches, styles, and intents. For example, a very sophisticated web-based homework grading and interactive tutoring system called "CyberProf"⁵ by the University of Illinois-Urbana involves extensive JavaScript and WWW server programming and serves thousands of students yearly. An initiative that is extremely sophisticated technically is the web-based introductory Chemistry course⁶ under development at Indiana University-Purdue University of Indianapolis (IUPUI). This initiative uses its technological sophistication to produce a web-enhanced distance learning environment. Representing a completely different mix of high technology and traditional mentoring techniques is the "Just-in-Time Teaching (JITT)"⁷ initiative underway in physics at the very same institution, IUPUI. The basic idea behind the JITT approach to using the WWW technology is to create a collaborative learning environment in which students work with web-based activities, submit their responses, and find that their classroom experiences are fundamentally shaped by what they have answered. A whole suite of web-based materials exists to support and engage the introductory physics students in a daily way, and these materials are fresh each semester.

In Summary:

Even a fairly casual survey of current WWW-based educational materials for physics indicates that, in this stage of infancy in the use of the WWW technology, innovations and initiatives are being tried and tested in a host of different directions, with a variety of intended goals and outcomes. In the opinion of the author, the best uses of the technology are those which use it to personalize and individualize instruction 24 hours a day, thereby accomplishing what the human faculty member and student cannot accomplish alone. In this way, the technology and the human each have vital roles. How to use the WWW technology to best create the partnership, with the ultimate goal of tailoring the learning process to each student's needs, will be the focus of many initiatives and assessments and much debate in the coming months and years.

References

- ¹ Johns Hopkins Virtual Engineering/Science Lab: <http://www.jhu.edu/~virtlab/>
- ² Davidson College physlets: <http://webphysics.davidson.edu/Applets/Applets.html>
- ³ Virtual Prof: <http://www.virtualprof.com/>
- ⁴ Cockpit Physics: http://www.usafa.af.mil/dfp/lessons/cp_home.htm
- ⁵ CyberProf: <http://cyber.ccsr.uiuc.edu/cyberprof/general/homepage/Newpage/first.html>
- ⁶ IUPUI Web Chemistry: <http://windmills.infolab.iupui.edu/c101/public/>
- ⁷ "Just-in-Time Teaching (JITT)": http://webphysics.iupui.edu/152_251_mainpage.html

For more information on JITT, see the following papers:

- World Wide Web Technology As a New Teaching And Learning Environment
International Journal of Modern Physics C
(<http://webphysics.iupui.edu/IJMP.html> or <http://www.wspc.com.sg/journals/ijmpc/81/ijmpc81.html>)
- Web Enhanced Physics with Just-in-Time Instruction
A National Research Council Invited Case Study
(<http://webphysics.iupui.edu/NRC/JITTnrc.html>)

The UK's Higher Education Teaching and Learning Technology Programme (TLTP): From Development to Implementation

Sarah Turpin, Teaching and Learning Technology Programme (TLTP)

Background and Introduction

Some four years, two phases, seventy-six projects and £40 million down the line, the world's largest technology based initiative is shortly to embark on its third phase. In July this year, the higher education funding bodies issued an invitation to UK institutions to bid for funding under a third phase of the Teaching and Learning Technology Programme (TLTP). Having focused, for the most part, on the development of new technology based materials for teaching and learning in the first two phases, the emphasis has now shifted to one of implementation, evaluation and dissemination.

Launched in February 1992, by the UK higher education funding bodies, TLTP has delivered one of the most comprehensive ranges of innovative new technology based materials for teaching and learning in higher education. The materials which cover a wide range of subject disciplines offer new and exciting approaches to teaching and learning. The majority of the materials have been developed to meet the needs of students entering their first year of undergraduate courses but some of the materials are also suitable for use in post-16 education and work-based learning programmes.

What does TLTP offer?

The seventy-six projects, covering business and economics, medical sciences, staff development and study skills, science, mathematics and computing, arts, humanities and social sciences and engineering, have developed materials which encompass application areas such as tutorials, revision materials, information retrieval systems, simulations, microworlds and communication tools. The inclusion of high levels of interactivity, graphics, animations, sound and video can contribute greatly to the student learning experience. Perhaps the most unique characteristic of TLTP is the extent to which the materials have been developed as a result of a collaborative effort by departments and institutions. In some cases, up to as many as 50 different institutions have participated in one project pooling the knowledge and expertise of a great number of academic staff to produce high quality materials. Through taking this collaborative approach there is no doubt that there is greater sense of ownership of the development process by academic staff and furthermore, it has begun to challenge the "not invented here" syndrome. Whilst there is still some way to go to completely overcome this syndrome, TLTP has certainly begun to challenge it.

TLTP was launched in the belief that the higher education sector could benefit as a whole from collective activity in the area of new technology based materials. Since the start of TLTP in 1992-93, the UK higher education funding bodies have continued to promote activities in the area of teaching and learning through a range of

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different initiatives to bring about the dissemination of good practice and to encourage ongoing collaboration between institutions. For example, the Electronic Libraries Programme, the Fund for Developments in Teaching and Learning and the Use of Metropolitan Area Networks Initiative.

The funding bodies recognised the importance of ongoing support and maintenance of the materials developed within TLTP and a further £4 million has been made available to existing projects to assist them move from mainstream funding to a self-supporting position. Of the seventy-six original projects, thirty-five have been awarded transitional funding and there are now eleven projects which have entered into agreements with publishers to market and distribute their materials worldwide. It will be the success of these projects in generating commercial income which will secure their long term viability.

Key Challenges

During the four years of TLTP, the funding bodies, projects, institutions and higher education community at large, have built up a considerable amount of experience and it is important that the learning which has taken place is captured and transferred between and across institutions. Inevitably, there has been much duplication of effort and reinventing of wheels within the programme but as long as the learning can be disseminated, these experiences can continue to benefit others in the longer term. Some of the key learning points for the programme have been in areas such as project management, development strategies, evaluation, dissemination and copyright and intellectual property rights.

Whilst TLTP offers a set of tools together with knowledge and expertise, these have to be seen within the organisational context of institutions which continue to face the challenge of delivering more teaching for less resources. As academic staff have to find new and more efficient ways of delivering their teaching, there will be increasing pressure to make use of new technologies and some of these will be in the form of TLTP type materials. Institutions are now having to address a number of major challenges such as:

- creating environments which foster and encourage innovation in teaching;
- developing teaching and learning strategies with technology as an integral part;
- keeping pace with technological advances;

- offering rewards/incentives for teaching; and
- providing staff development and training for teachers.

TLTP Phase 3

The third phase of TLTP is intended to provide an opportunity for institutions to begin to address some of these challenges. The main aims of this phase are to:

- support institutions in embedding the use of technology based materials for teaching and learning more firmly within higher education;
- explore and adapt ways to deliver such materials that will be applicable to a range of subjects in many institutions; and
- evaluate the cost and educational effectiveness of such materials.

The main objectives are to encourage the take up and integration of TLTP materials and other technology based materials into mainstream teaching and learning as well as explore, adapt and disseminate experiences from integrating such materials, to identify successful approaches that can be applied generically, rather than just to specific subjects.

Whilst the funding bodies may fund a very small number of new development projects, most of the funding will be used to support implementation projects. Funding of £3.5 million annually for the next three years has been made available for this phase of the programme. It is anticipated that new projects will get up and running in April of next year.

Teaching and Learning Technology Support Network (TLTSN)

In order to provide the higher education sector with additional expertise and experience in the implementation of technology based materials, nine support centres have been established to form the Teaching and Learning Technology Support Network. These centres are being centrally co-ordinated by the TLTP Co-ordination Team and exist to provide the sector with free guidance and support to integrate technology into teaching and learning. The particular focus of the Network is to assist senior management within institutions to look at strategic planning for technology in teaching and learning, to support organisational and technological change and to assist with the

formulation or review of learning technology policies.

This Network of centres has now been up and running for two years and will continue its work through to the end of 1998. The centres participate in a wide range of activities within institutions such as meeting with key committees and/or decision makers, running focused workshops on different areas of

teaching and learning technologies, one-to-one consultations for those with specific responsibilities in these areas and attendance at institutional events. They have also produced a series of case studies drawn from their own institutional experiences.

The TLTP URL is <http://www.tltp.ac.uk/tltp/>



UniServe Science Workshop



PRELIMINARY ANNOUNCEMENT

University Science Teaching And The Web

**The University Of Sydney,
Friday-Saturday February 13-14 1998**

UniServe Science is intending to hold its third workshop, entitled *University Science Teaching and the Web* in the second week of February next year. The names of prospective contributors are being sought.

Are you using the web for teaching?

We seek expressions of interest from anyone who would like to present a paper or lead a hands-on session during that workshop.

Do you know of others using the web for teaching?

We seek suggestions for potential presenters who could be approached for the workshop.

Are you interested in finding out how to use the web in your teaching?

An email message will soon go out to everyone on our mailing lists asking for tentative enrolment.

Workshop costs will be kept to a minimum, but unfortunately travel assistance cannot be provided as for previous UniServe Science Workshops.

Proceedings of previous UniServe Science Workshops are available at <http://science.uniserve.edu.au/su/SCH/pubs/procs/>

The BioNet Project: Beyond Writing Courseware

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In the United Kingdom, the development of information technology (IT)-based teaching has been supported by two centrally funded initiatives — the Computers in Teaching Initiative (CTI) in the late 1980s and, more recently, the Teaching and Learning Technology Programme (TLTP). The BioNet TLTP project was conceived by individuals who had been active in the early phase of CTI. They had produced teaching material that had won external awards, but they had found that courseware production is relatively easy compared with the much more difficult task of changing courses and attitudes in order to get it used. They saw in TLTP the means of using the funding councils' money to lever the required changes into place. Furthermore, the requirement for consortium-based projects gave the opportunity for the experience that they had gained to be transferred to staff at other sites who were just starting to introduce IT-based teaching. The objectives of the project can be summarized as follows: (i) the integration of IT-based teaching material into our mainstream timetabled courses; (ii) producing and quantifying the institutional change necessary to allow this to occur; (iii) training a cadre of academics who can author, re-author and maintain the IT-based courseware without the need for specialist programmers; and (iv) to leave behind something of worth that can be continued after the end of external funding.

The project, funded for 3 years from October 1992, had a part-time director, 18 full members and 5 affiliate members. The membership represents 17 U.K. universities. Full members actively implemented the project in their departments and received partial salary support, consumables and travel/workshop expenses. Affiliate members were those who were not in a position to implement the project from October 1992 (usually due to lack of equipment), but kept a watching brief with the aim of fully joining the project when possible. They received expenses only. In October 1993, two affiliate sites became full members, and a third affiliate changed to full membership in October 1994. All sites had at least one member of academic staff who was responsible for implementing the BioNet project in his/her department and acting as contact person. Most full members used their partial salary allocation to support a further resource person with responsibility for IT-based teaching. One site used the allocation to free the contact academic from some departmental duties so that she could concentrate on BioNet-related activities. Another site used its salary allocation to provide postgraduate demonstrator support for BioNet-supported IT-based teaching. The consumables allocation to each full member allowed the purchase/upgrading of software etc. (It is much easier to get IT-based teaching going if you are not perceived as a drain on departmental funds.) The project was run by a management committee consisting of the director and representatives of the three lead sites (Leeds, Aberdeen and St. Andrews). Day-to-day communication within the project took place via a Mailbase electronic mail list.

Training academic staff to author, re-author and maintain IT-based courseware was an important aspect of the BioNet project.

Each year we held a main workshop at St. Andrews. Open to members and non-members, these were always well-attended. Topics covered included an introduction to *ToolBook* and *HyperCard*, animation techniques, and teaching resources and the Internet. The consequence of these workshops is that, although software production was never a main objective of the BioNet project, a considerable amount of teaching material has been accumulated. Some of this material pre-dates TLTP, but much has been produced by our members in response to educational need in their courses and those of others.

All of this material has been made freely available so that others can modify it to their own local requirements. To achieve this, we initially set up an archive of this material which could be accessed by file transfer protocol (FTP).

However, we became increasingly concerned that simply making material available may be counter-productive in some cases. The context in which the material is meant to be used is very important. For example, it can be disastrous if teachers try to use as a self-taught tutorial a simulation program intended for use in supervised practical classes. On the FTP server, most of the courseware items were accompanied by descriptive text files, but there could be no guarantee that the users would read them. We published (on paper) the contexts of our material in our Directory and Software Compendium in 1993 and distributed it widely, but we really wanted to find a way in which the context could be delivered with the software it described. For this reason we decided to use the World Wide Web as our preferred delivery system.

The URL of our home page is <http://www.leeds.ac.uk/bionet.html> On this server we mounted our Software Compendium. Organized by subject area, each entry is accompanied by at least one page of context and a further page giving technical details. A simple hypertext link allows the FTP server to be accessed and the software item to be downloaded. In addition we are now exploring ways in which the Web can be used as a teaching resource in its own right.

Despite the large amount of material in our software archive, software production was simply a by-product of the BioNet project. Our real deliverables were defined in terms of the amount of IT-based teaching material incorporated into our courses. Our measure of this was the Directed Information Technology Time (DITT). DITT is defined as the number of hours within the timetable of a course that have been replaced by IT-based teaching. It does not take into account the number of students involved, the number of staff involved

or any circling (repetition) arrangements. It does not include any non-timetabled activities. It is therefore a very conservative estimate of the IT-based teaching going on in any course, but its strict definition precludes the spin-doctoring that could happen if multipliers were allowed for staff or student numbers.

Nonetheless, in order for IT-based teaching to be timetabled it must replace conventionally taught material, and hence DITT gives a good measure of institutional change.

We measured the amounts of supervised and unsupervised DITT in both tutorial-type teaching and practical class-type teaching. Each BioNet member was asked to supply DITT figures covering the academic year 1991/2 (before TLTP) through to academic year 1994/5. From the information provided on 80 courses, we calculated:

IT Intensity = total DITT/total timetabled teaching time x 100%

Staff Efficiency Gain = total unsupervised DITT/total timetabled teaching time x 100%

Flexible Learning Time = total supervised DITT/total timetabled teaching time x 100%

The results are summarized below. The overall IT intensity approximately doubled during the first year of the BioNet project (1992/3), and the rate of increase was maintained into the academic year 1994/5. Since the estimate of IT intensity only applies to timetabled teaching, the increase reflected a switch from conventionally taught material and clearly represented a considerable change in the pattern of teaching. The proportion of unsupervised DITT within this total ran at about 50% and was reflected as a steady increase in staff efficiency throughout the period of the project. The staff hours saved were based on a simple saving in contact time arising from the unsupervised DITT within the timetabled course hours. This saving in contact time also reduced the didactic course content and released an equal amount of individual undergraduate time for self-paced learning. The average class size increased during the period of the project, and there is no doubt that the application of IT-based teaching was an important factor in our members' ability to cope with increasing student numbers. For those who like rather meaningless large numbers, if we calculate John Slater's 'bum-seat hours', in the 80 courses for which we have data, the number increased 7-fold from 49,000 before the project started to 345,600 in 1994/5.

Provision of computing equipment has been a major influence throughout the project. As set out in our original proposal, we had hoped to

Summary of timetabled IT-based activity within 80 courses taught by BioNet members

| Session | Average class size | DITT (h) | IT intensity | Flexible Learning Time | Staff Efficiency Gain | Staff hours saved | Average c.p.u. per class |
|---------|--------------------|----------|--------------|------------------------|-----------------------|-------------------|--------------------------|
| 1991/2 | 64 | 760 | 4.4% | 2.4% | 2.0% | 344 | 44 |
| 1992/3 | 71 | 1603 | 8.5% | 4.3% | 4.2% | 797 | 58 |
| 1993/4 | 87 | 2463 | 12.2% | 6.0% | 6.2% | 1257 | 62 |
| 1994/5 | 108 | 3194 | 16.5% | 8.1% | 8.4% | 1619 | 74 |

achieve an overall IT intensity of 20% by the end of the project. In retrospect, this was probably over-optimistic, since it assumed that adequate numbers of personal computers would be available. In fact, at many sites, adequate facilities were slow in coming. In their reports, our members were asked to indicate how many computers their students had access to. The result is included in the table above. Note that the figures do not represent exclusive access, but simply the availability of the equipment. As TLTP started, some institutions responded by providing increased numbers of machines, and this is reflected in the increase in 1991/2 to 1992/3. However, this rate of increase did not continue through the second year of the project and only took off again in the third year, probably in response to the increased number of undergraduates.

Summative evaluation of the project was carried out via the DITT survey detailed above. Courseware evaluation was delegated to each site. As IT-based teaching material was introduced, it was subject to departmental evaluation procedures. At some sites, evaluation was conducted internally using student questionnaires. At others, evaluators from outside the department were brought in. Formative evaluation of the project was carried out by the project's full time Evaluation Officer. On behalf of the management committee, he carried out an evaluation of the operation of the project at each site, paying particular attention to local factors that affect the success or otherwise of the project. His reports showed how important is the modest funding that each site receives in terms of giving the contact person 'leverage' when negotiating changes in courses.

We identified several factors that have aided our members in integrating IT-based teaching into their courses. These can be summarized in the following advice:

- (i) Only use IT-based courseware to meet clearly identified educational need in actual courses, not simply because the technology is available.
- (ii) If suitable material already exists — use it. Use electronic mailing lists and news lists to enquire if anyone knows of existing material. If

a standard productivity package such as a spreadsheet can be used, it represents a much more efficient use of your time (and your colleagues') than designing material from scratch. Only write new courseware as a last resort.

(iii) If you have no alternative to producing new courseware, then it should be easily re-authorable using simple authoring tools. Re-authorable software can get past the 'not invented here' problem and will allow the material to be updated to include new knowledge. It should be produced by the person who is initially going to use it. Enthusiasm and knowledge of the subject are much more important than programming ability. Do not delegate to someone less familiar with the subject material. Hence there has been no BioNet funding for teams of programmers. Share the load, by collaborating with others if they are interested, but do not design by external committee. It should be short: no more than 20 minutes running time. Do not attempt to produce complete courses. Multimedia production is slower than the development pace of most subjects in higher education. The larger the piece of multimedia you try to produce, the more likely it is to be out of date or superficial. It is much easier to integrate several short pieces of IT-based material into courses than a few large ones.

(iv) The courseware should not require hardware other than that readily available. There is no point acquiring or producing sophisticated multimedia courseware if you don't have the hardware to run it now with meaningful numbers of students.

(v) The IT-based material must be incorporated into mainstream timetabled courses and should be included in the same evaluation procedures as conventional teaching material. If you simply 'make it available' or imply that it is 'remedial', neither your students nor your colleagues will take it seriously and you will have effected little or no long-term change. If you have successfully integrated IT-based teaching into your courses, make sure that it is evaluated alongside conventional teaching. Don't subject it to different procedures that make it look 'special' — it isn't.

Third International Conference on Computer Based Learning in Science, 1997

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The conference was held at De Montfort University, Leicester Campus on 4th July - 8th July 1997. It was the third conference in a series organised by academics with an interest in the use of computer based learning to enhance teaching and learning. The first conference in 1993 was held at the Technical University of Vienna and the second in 1995 at the Silesian University Opava in the Czech Republic. The majority of delegates at the third conference came from the UK, Eastern Europe, and further east (India, China) with a small but vocal contingent from Canada and Australia. Unlike most conferences, there were no keynote speakers. Instead there were 61 scheduled papers in a single stream over four days. There was little focus for the conference and the papers that were presented were of mixed quality. The sessions were mostly devoted to the physical sciences, earth sciences and engineering with a recurrent theme of how teaching could be implemented with the use of the Internet — a bit like using technology for technology's sake and in this case — the Internet. There was an emphasis on “doing things” but with little pedagogical consideration of the materials produced or how they are being

delivered or used. Formative evaluation during development had not really been considered by most developers and peer/student evaluation of the product was, for the most part, missing. I felt a sense of *deja vu* and that Eastern Europe and further east were just getting on the band wagon. Reinvention of the wheel was greatly in evidence and always with an excuse of why it had to be.

Memorable presentations included one by Alan Cann from University of Leicester on the delivery of on-line interactive CAL delivered via the Web as a dynamic open learning resource. The system is being developed to create a virtual teaching environment for medical students and this includes on-line lecture notes, on-line information sources (search engines), video materials, interactive tutorials, electronic submission of assignments, asynchronous communication using email, and testing scenarios.

The social activities of the conference took us on a walking tour of old Leicester and drinks with the Lord Mayor, to Stratford to visit Shakespeare's birthplace, on a tour of the Leicestershire countryside and to many pubs ...

UK Earth Science Courseware Consortium Annual Users Meeting, 1997

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This was a two day event held in sunny Manchester. The first day was devoted to using courseware for geoscience teaching and learning. The TLTP materials were much in evidence — the 1997 catalogue was just out. The University of Manchester (which sits on a node of SuperJANET — the academic internet in the UK) has set up a TLTPZone which can send out TLTP across the campus. There are over 200 modules within the service and it is expected that the TLTPZone will be capable of handling other CAL materials. The current status of the UKESCC material is that it is for sale to students and to institutions (£6 per module or £30 per CD). It has been sold to

over 20 countries, including Australia and New Zealand. The next stage in the TLTP program is to integrate the courseware into curricula and the geosciences courseware is also looking at being shocked onto the Web (it was developed using *Authorware*). Papers given on student evaluation of using the UKESCC TLTP modules (by the Open University), and on integration of the courseware with other teaching and learning activities (University of Luton) were well received by the meeting.

A highlight of the meeting was a demonstration of *Mineral Master*. This is essentially a series of databases on mineral structure, chemical composition, physical

properties etc. which are so linked that movement from one to another is seamless. The CD allows teachers and/or students to find out about minerals in an interactive way. There are 700 high resolution images of minerals, crystal structures and crystal drawings. The software comes from Canada and will be reviewed in the next newsletter. It is for sale at a reasonable price (enquiries to UniServe Science).

The second day of the two-day program was to look at the use of the Internet in geosciences

teaching. Speakers came from USA, Canada, Ireland and the UK. There were some innovative ways in which the geoscientists have been developing web materials and using them in teaching. There was a lovely virtual field trip, developed to cope with the increasing costs of taking students around the country although every geologist and geographer there said you could not replace the "real" thing, but that a pre-field trip program would help students get the most out of the real experience, although the virtual field trip lacks a pub at the end of it!

UniServe Workshop: Putting You in the Picture

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UniServe's workshop 'Putting you in the picture', held in Newcastle 15-16 July, 1997 was organised to demonstrate innovative ways of finding, handling and manipulating images to enhance teaching materials. The workshop was sponsored by UniServe Science, UniServe Health and the UniServe Coordinating Centre.

With the rapid rate of change in technology over the last few years we are all surrounded by and constantly bombarded with visual effects. Consequently, to attract and hold a student's attention teachers are now, more than ever before, searching for graphic images. In addition, the enhancements in technology now make it feasible to have, and very effectively integrate into teaching, combinations of video clips, animations, sound and graphics. However, keeping abreast of what is available, where to find it and how to use it are constant concerns for teaching academics who are already stretched to the limit.

The programme was a combination of presentations, hands-on sessions, posters and informal discussions. Presentations covered: the educational aspects of teaching, such as, the move from teacher centred learning to student centred learning; logistical problems, such as, large classes and the requirement to teach more with less resources; collection, storage and retrieval of multimedia based information; and the value of images. The two opening papers addressed issues relating to teaching and new technologies in general. These provided a background for the later papers on specific uses of images in teaching. The hands-on sessions were on specific software packages. The first, on the challenging *Adobe PhotoShop*, enabled participants to create quite stunning effects in a relatively short time. The second was on the

more user friendly *Microsoft PowerPoint*. This session proved useful for both novices and those with some prior experience.

Unfortunately, as often happens, everyone wanted to see more but time ran out. Although there were only a few posters, between them they spanned the use of images in tertiary teaching: the use of imagery via video conferencing; multimedia use of graphics and animation; and the use of cable television.

It was apt that the final paper of the workshop exemplified the practice of a good presentation. The paper from Ric Lowe, Curtin University, titled 'How much are pictures worth?' was excellent in both content and presentation. He pointed out that the 'reading' of a picture is very complex. Aspects of it that seem obvious to the teacher may be completely missed by the student. One's interpretation of a picture is a combination of the knowledge brought to the viewing and that which is built up during the viewing. For the student to gain the intended learning benefit it may be necessary for the teacher to guide the student through the picture, such as: where to look; what are the elements; the sequence to follow; and how to connect the information.

As with most workshops the information and knowledge gained from the formal sessions were only a part of the valuable experience. It was a good opportunity to put faces to emails.

The proceedings of the workshop are available in PDF from the UniServe Science web page <http://science.uniserve.edu.au/su/SCH/pubs/>

Geology of Australia

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Geology of Australia is an introduction to earth sciences and a comprehensive illustrated guide to the geology of Australia.

Facilities and capabilities of the package

This hypermedia package consists of two CD-ROMs. The package is essentially a digital text book. The content is organised into six sections as follows: 1. Introduction to Earth Sciences; 2. Minerals and Resources; 3. Topographical and Geological Maps; 4. Geological Time; 5. Principle Geological Features; and 6. Geological Atlas. Each of these sections is divided into a number of subsections. For instance the introduction to Earth Sciences section is subdivided into forty-three topics each of which has a number of accessible screens ("electronic cards") which are portrayed on the computer screen as a sequence of labelled files. These can be individually selected by clicking on file labels. Most screens consist of text and images. Highlighted key words in the text can be selected for additional information. Images can be individually selected to give an expanded view of diagrams and photographs as well as additional information in the form of text notes. Navigation from one topic to another within this particular section is facilitated by scrollable text boxes listing related topics to the selected topic in view on the computer screen. Other sections include video, digital gazetteer and some simple interactive maps and graphics. Operational and image design varies between sections.

System Requirements

IBM-compatible PC (486 or higher), *Microsoft Windows 3.1* or higher supporting 640x480, 256-colour SVGA, 4Mb RAM, 6Mb free hard disk space, Mouse, CD-ROM drive, sound card and speakers or headphones.

Ease of use

Once installed the program is easy to use as it adopts a mostly conventional hypermedia approach which includes "buttons", "scroll bars", "drag bars" or "hot text" to navigate through aspects of the program.

Suitability for use in teaching

This software is suitable for a self-paced, theoretical, learning program for students on introductory geology, although it does not have a stand-alone teaching and learning structure. The program has a number of additional resources such as digital Geological Atlas that may be usefully compiled into a broader teaching materials framework of a conventional course on Introductory Geology.

Area of application and intended users

Clearly this program does not substitute for an Introductory Geology course that is designed as the initial part of an university undergraduate program leading to the training of professional geologists as it is not suitable for teaching students practical or field skills. However the program may be used as a part substitute for theoretical aspects of lectures on Introductory Geology. The program would be especially useful for non-professional geoscientific oriented education programs at a senior secondary school or first year university level.

Coverage of material

The computer program gives an acceptable coverage of topics common to lecture programs for Introductory Geology courses, although aspects of Structural Geology are under-represented.

Accuracy

The information provided in this software package is scientifically accurate.

Overall evaluation

The teaching resource materials of this software are extensive and most teachers of Introductory Geology courses would find the content of these CD-ROMs a helpful adjunct to their courses. At the current price of \$99.00 the product is very good value.

(See page 17 for product information)

Powersim 2.5C

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Powersim is an object-oriented package for the construction of interactive simulation models.

"This is the first laboratory session on simulation modelling. Let us construct a model of a drainage system. We will begin by creating a rainfall input sub-model with a Monte-Carlo distribution of n rain-days per year, and a log-normal distribution of rainfall amount on the rain-days."

That statement is typical of the way I do start my sessions on simulation modelling. Using *Powersim*, the above task is accomplished by positioning one screen object, and, with the aid of built-in functions, inputting a fairly straightforward equation. Add a graph using drag-and-drop methodology, and one's students may then run the sub-model for a year of simulated time and see the rainfall pattern develop, all within minutes of commencing the practical session.

Powersim is one of several object-oriented packages available which allow rapid construction of simulation models in a systems dynamic framework, using visual objects, point-and-click, and drag-and-drop techniques. A powerful heuristic feature of these packages is that they allow for the on-screen construction of a flow-chart style representation of a model, in much the same way one would develop a conceptual flow chart on paper before writing a model in a programming language. But this is where the similarity to conventional programming ends, for, having constructed the on-screen flow chart in *Powersim*, one has only to add the governing equations in order to begin a simulation. The package thus allows users to concentrate on the intellectually stimulating and creative aspects of simulation modelling, and skip the tedium and frustration normally associated with the process. Other examples of the modelling genre are *Optima!*, *Simul8*, *Dynamo*, *iThink*, *STELLA*, and *Vensim*. The author has some familiarity with all of the latter packages, with extensive experience of *STELLA* and *iThink*. Indeed, for some time *STELLA* was used for all of our classes on simulation modelling. However, our Department has changed over to *Powersim*, for a variety of reasons, most of which have to do with its excellent range of features, such as:

* *Powersim* has the capacity to toggle between two levels of utilisation, with a simplified user interface that allows beginners to learn in a non-threatening and relatively uncomplicated environment whilst at the same time actually using the full strength product. Any work done in the simplified environment does not have to be re-done to run in the fully featured environment, and models constructed in the latter may be run in the simplified environment.

* *Powersim* has over 150 built-in functions (about twice as many as *STELLA*)

* *Powersim* has a wide variety of objects for the presentation of simulation results: two-dimensional X-Y graphs, histograms, one-dimensional by time graphs, speedometer style gauges, simple numeric display, or tables. Add to this the capacity to readily import illustrations, and one may construct a display interface (complete with slider buttons to alter inputs whilst the simulation is in progress) on one page of the model, with all of the "plumbing" on a second page.

* For serious users, *Powersim* supports Dynamic Data Exchange (DDE) using standard Windows protocol (essential if one wishes to calibrate one's model with reference to real-world data stored in a spreadsheet, say), and also boasts an Application Programmers' Interface (API) which allows programmers to connect *Powersim* applications to programs developed in C++, Visual Basic, or Delphi (for example, one may wish to employ *Powersim* as the simulation "engine" in a model which does not have simulation as its main function).

In the retail market, *Powersim* is somewhat more expensive than the other products mentioned, but for educational users, there is little difference in price. Some colleagues may also be interested to know that, at the time of writing, cross-upgrades to *Powersim* are available at an attractive rate. To download demo: <http://www.powersim.no/>

(See page 17 for product information)

BioXplorer Plus

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BioXplorer Plus (BioXP) is, according to its creators, a program designed to help students understand the material presented in the 6th Edition of the textbook "Biological Science" by J.L. Gould and W.T. Keeton. The software package consists of four set-up disks; a single-page installation instruction sheet is also provided. No additional hardcopy information is included. Both PC and Mac versions are available. Minimum system requirements for PC's are *Microsoft Windows 3.x* or higher and 8MB of hard disk space. Minimum system requirements for Mac's are Macintosh 040 computer or better with *System 6.5* or higher; 8MB of RAM, a monitor that can display 256 colours and 10.5MB of free hard disk space.

Installation instructions are clear and straight-forward; the user can choose either the full or custom installation option. Minimal computing skills are necessary to install the software and run the program.

BioXP is very easy to use and highly intuitive in its operation allowing first time users to get up and running quickly. Clicking on the Help button provides an on-screen display of instructions on how to use the program effectively; instructions are easy to read and understand. The program provides a comprehensive treatment of the six parts covered in the textbook: I. The Chemical and Cellular Basis of Life; II. The Perpetuation of Life; III. Evolutionary Biology; IV. The Genesis and Diversity of Life; V. The Biology of Organisms; and VI. Ecology. *BioXP* is split into three linked modules: a tutorial book with simulations, a quiz book and an interactive glossary. The user can easily and quickly navigate through all three modules.

Each screen in *BioXP* provides key notes on selected material from the textbook together with drawings, graphs and animations of selected concepts. At the bottom of each screen are well-defined buttons which help you to easily navigate through the program and provide access to auxiliary learning aids such as the Glossary and Quiz modules. The information provided is, for the most part, accurate and user-targeted. As its creators rightfully point out: "Since the textbook is effective in presenting detailed illustrations and factual information, this program should be used as an adjunct to, and not a substitute for, the textbook."

Positive aspects of the program include: Well-structured, very user-friendly, computer-aided presentation of selected factual material and concepts drawn from the accompanying textbook. Although some attention to multimedia styling is needed, *BioXP* generally has a visually pleasing style presenting information in an easy-to-read format so that the learning process should be an enjoyable one. In this regard, the very clever mix of animation, video material and interactive questioning will help students better understand key concepts in biological science. Instructions are clear and informative. Control buttons allow for very easy and fast movement around the program; it has a really intuitive feel. Hypertext functions are very effective. The multiple-choice question module in *BioXP* can be accessed at any time with the click of a button. The users are informed as to whether their answers are correct or incorrect and a running score is also available; descriptive feedback is displayed for a correct response. A comprehensive glossary complements the package; access is available via an on-screen control button or via a hypertext function within an information screen. Key notes and concepts presented on-screen in *BioXP* can be directly related to textbook information since the corresponding chapter and page numbers appear at the top of the screen. An additional noteworthy feature is that the user can make on-screen notes which may be saved and/or printed.

Negative aspects of the program include: No control buttons to allow the user to print on-screen information; students frequently request such an option. Some additional attention to multimedia styling (on-screen presentation of graphics, artwork and text) is needed. No feedback given for incorrect responses in the multiple-choice quiz.

Overall, for university-level students studying general biological science or related speciality areas, *BioXP* is a potentially useful and exciting teaching/learning aid, particularly with its mix of animation, video material and interactive questioning. However, to maximize its value as a learning tool it must be used in conjunction with the textbook.

(See page 17 for product information)

Contemporary Laboratory Experiences in Astronomy (CLEA)

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The *CLEA* astronomy laboratory exercises are engaging, reasonably realistic simulations of what professional astronomers actually do, and help to teach some useful astronomy concepts in the process. We are using several of these labs. as a major component of our undergraduate astronomy courses at La Trobe University. There are eight exercises which have windows-based versions:

The Revolution Of The Moons Of Jupiter
Purpose: To illustrate the measurement of the mass of a planet using Kepler's third law.

The Rotation Of Mercury Using Doppler Radar
Purpose: To illustrate the measurement of the rotation rate of a planet using the Doppler shift of a returning radar pulse.

The Flow Of Energy Out Of The Sun
Purpose: To illustrate radiative transfer in stellar interiors and stellar atmospheres and the formation of spectral lines.

Photoelectric Photometry Of The Pleiades
Purpose: To familiarize students with the technique of photoelectric filter photometry and counting statistics, and to introduce the use of H-R diagrams for analyzing the age and distance of clusters.

The Hubble Redshift Distance Relation
Purpose: To illustrate how the velocities of galaxies are measured using a photon-counting spectrograph, and to estimate the value of the Hubble parameter and the expansion age of the universe.

The Classification Of Stellar Spectra
Purpose: To introduce students to the process of classifying different spectra by the relative strengths of lines, and to familiarise students with the sequence of spectral types.

Large Scale Structure Of The Universe
Purpose: To understand how astronomers use the redshift-distance relation to map out the cosmic structure of the galaxies.

Radio Astronomy of Pulsars
Purpose: To take simulated measurements of signals from several pulsars at various radio-

frequencies and learn about the observational properties of pulsars. The radio telescope has optional features which can be used for additional labs.

With some judicious editing, these simulated free-ware labs. can all be used for 3-hour introductory astronomy sessions at first year undergraduate level, although sections of some labs. (Hubble Redshift, Large Scale Structure, Pulsars) are better suited to more advanced courses. Some (Moons of Jupiter, Rotation of Mercury) could probably be modified for use as project work at secondary school level. We have found the Sun lab. the least useful of the set, but in general they are easy to use and professionally produced with clear student instructions, simple to install, and a boon to any astronomy coordinator wondering what lab. to give students on cloudy winter days!

For more information, visit the *CLEA* site at <http://www.gettysburg.edu/project/physics/clea/CLEAhome.html>

Product Information

Geology of Australia is available from:
CD Vision
83 Beatrice St
Balgowlah Heights, NSW 2093
Tel: (02) 9948 5540
email: visioncd@ozemail.com.au

Powersim is available from:
Synergy International Consulting Pty Ltd
31 Frater St
East Kew, VIC 3102
Tel: (03) 9859 7322
email: sipower@ozemail.com.au

BioXplorer Plus is available from:
Jacaranda Wiley
PO Box 1226
Milton, Qld 4064
Tel: (07) 3859 9755
email: headoffice@jacwiley.com.au

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An Interactive Multimedia Package Designed to Improve Beginning Students' Understanding of Chemical Equations

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Introduction

Reviews of alternative conceptions research (e.g. Garnett, Garnett & Hackling, 1995) indicate that it is difficult for introductory chemistry students to develop adequate conceptions of the unobservable entities (atoms and molecules) and events involved in chemical reactions. The difficulties students experience visualising the submicroscopic particulate nature of matter and the processes involved in chemical change represent a major barrier to the development of a scientifically valid understanding of many chemistry concepts. As a result, beginning students often exhibit a wide range of alternative conceptions about the molecular basis of chemical reactions and this subsequently affects their ability to write balanced equations, interpret the symbolic representations used in equations and solve problems based on equations.

Johnstone (1991) proposed that chemistry is taught at three levels. The macroscopic level is sensory and deals with tangible and visible phenomena (e.g. salt dissolving in water). The submicroscopic level provides explanations at a particulate level (e.g. disruption of the ionic lattice with ions, surrounded by water molecules, moving into solution). The symbolic level represents processes in terms of formulas and equations (e.g. $\text{NaCl(s)} + \text{H}_2\text{O(l)} \rightarrow \text{Na}^+(\text{aq}) + \text{Cl}^-(\text{aq})$). Johnstone believes that insufficient attention is given to understanding chemistry at the submicroscopic level and has pointed out the difficulty for students when teachers move quickly between these different levels.

From the available research evidence it appears that students have most difficulty in dealing with the submicroscopic which is, of course, outside their experience and can only be made accessible to students through the use of models, analogies or computer graphics. Interactive multimedia materials are ideally suited to the simulation of the submicroscopic/particulate nature of matter in its various states and the processes involved in chemical change. Tasker, Chia, Bucat and Sleet (1996) have reported recently on the VisChem Project which has developed molecular animations of a range of chemical processes aimed at improving

students' understanding of the molecular basis of these processes.

Description of the project

This project developed an interactive multimedia package designed to help beginning students understand the particulate basis of chemical reactions, their symbolic representation as chemical equations and to apply this understanding when balancing equations and solving simple problems based on equations.

The materials were designed to expose students to the three levels of chemical knowledge described previously, i.e. the macroscopic, submicroscopic and symbolic levels, and provide an understanding of the particulate basis of chemical reactions. As well it was intended that the program provide opportunities for students to learn and practise the skills of balancing chemical equations. Finally the program aimed to develop students' skills in interpreting chemical equations at a quantitative level including an understanding of the concept of limiting reagent.

The project has developed three discrete modules that introduce students to chemical equations and develop skills in balancing equations and their interpretation. The materials are designed for use in direct teaching, tutorial or self-instructional modes. Two modules deal separately with 'molecular' and 'ionic' equations. A third module provides students with practice in the interpretation of equations.

Modules 1 and 2 both include instruction relating to eight chemical reactions. For each of these eight reactions students can:

1. View a video demonstration transformed into computer images (Figure 1). These images are intended to show students the actual appearance of a reaction when it occurs in real life. The purpose of this macroscopic view is to provide a link between the real world and the submicroscopic/particulate models chemists use to interpret chemical reactions;
2. View a simulation of the reaction at a particulate level (Figure 2); these animations use dynamic graphics that illustrate the behaviour of atoms and

molecules and the transformations they undergo in chemical reactions. The animations are designed to represent, at a particulate level, the processes that occur during chemical reactions using information that is available about these processes. In some examples, where these processes are very complex, the process animations are simplified;

3. Write a balanced chemical equation (Figure 3). Equations are used to represent chemical reactions at a symbolic level. Students are provided with a particular approach to the balancing of equations which enables them to scaffold

their knowledge. In this interactive program students are provided with a word equation and are asked to enter the formulas of each of the substances involved. Feedback is provided in relation to the chemical formulas written and also on the coefficients used to balance the equations. An option allows students to enter the physical states of all the substances involved.

Practice sets of twenty additional reactions are provided with both these modules to give students further practice in writing balanced chemical equations.

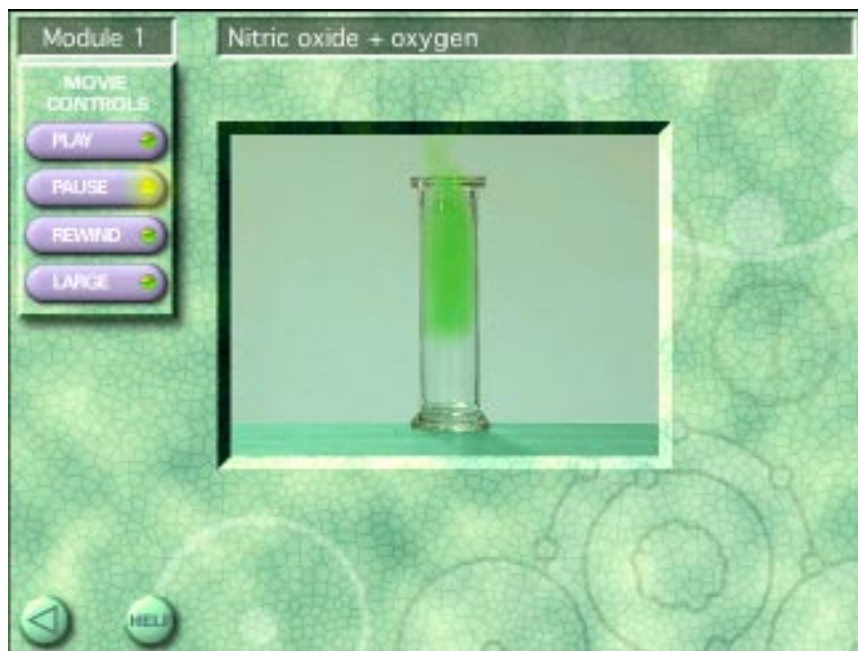
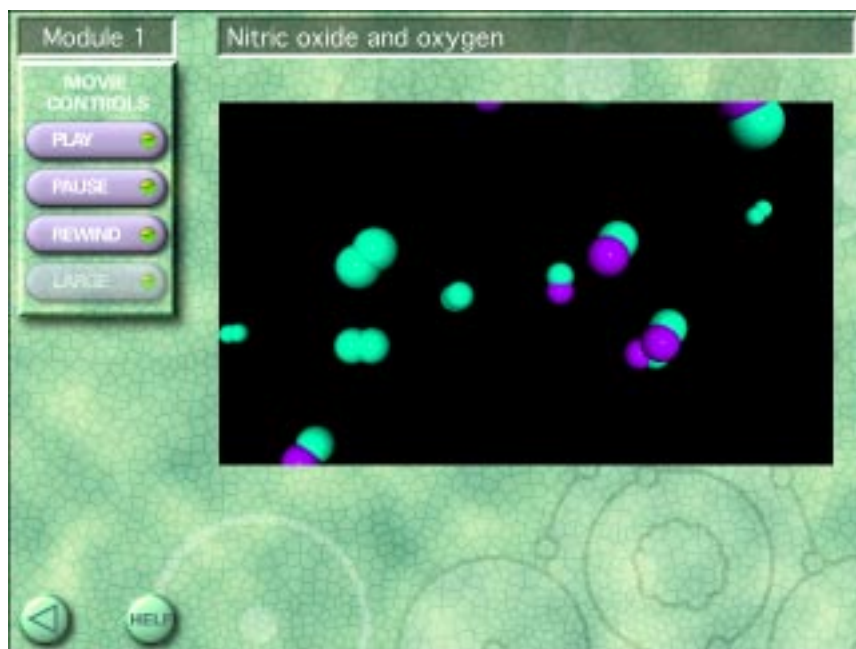


Figure 1. Video of a laboratory demonstration of a chemical reaction.

Figure 2. Simulation of a chemical reaction at a molecular level.



Module 1 Equation

Now, let's see if you can write an equation for this reaction.
Start by writing in the formulas for each of the substances involved in the reaction.

Use the **shift** key for capitals and superscripts, and the **option** key for subscripts.
Press **return** to check the formula.

NO + →

nitric oxide oxygen nitrogen dioxide

← HELP →

Figure 3. Interactive program for learning to write chemical equations.

In Module 3 students develop their understanding of what chemical equations represent and their skills in interpreting equations. They are asked to interpret equations by drawing “before” and “after” diagrams to represent what occurs in a chemical reaction (Figure 4); do simple calculations to

develop an understanding of the meaning of coefficients in chemical equations; and write equations to represent reactions illustrated by “before” and “after” diagrams (Figure 5). The concept of limiting reagent is introduced in some sections of this module.

Figure 4. Drawing “before” and “after” diagrams to represent a chemical reaction.

Module 3 1.1 Construct molecular representations of equations

Construct a molecular representation of the equation below. Use the mouse 'click and drag' to select molecules from the 'molecular key' and place the correct number of molecules into the 'before reaction' and 'after reaction' boxes.

N_2 H_2 NH_3

BEFORE REACTION AFTER REACTION

← HELP $N_2 + 3H_2 \rightarrow 2NH_3$ CHECK ANSWER →

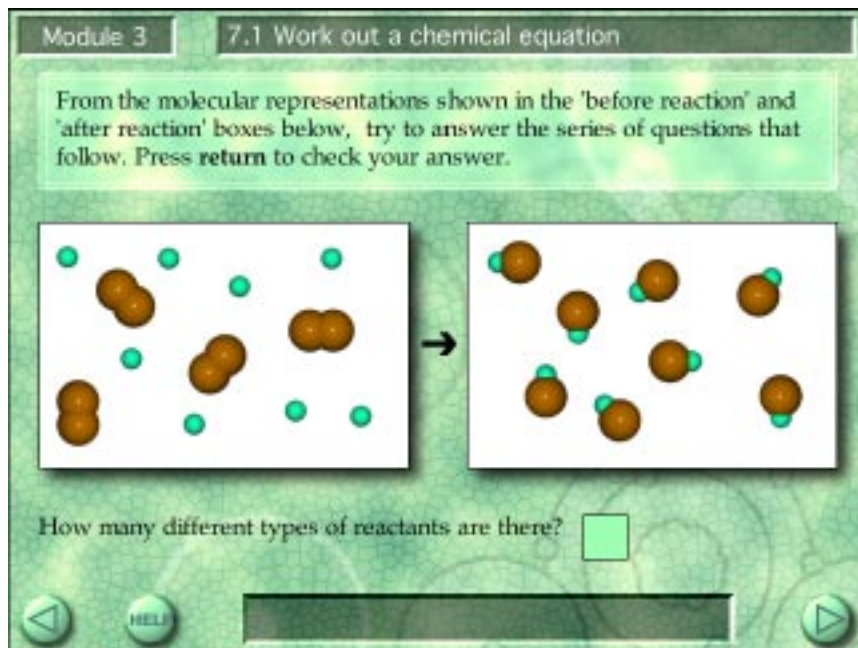


Figure 5. Writing equations from “before” and “after” diagrams representing a chemical equation.

Conclusion

This IMM package was designed to improve students' understanding of the particulate/molecular basis of chemical reactions, and their ability to balance and interpret chemical equations. The provision of concrete representations of unobservable entities and processes, and the use of an interactive approach with associated feedback should facilitate students' achievement of scientifically acceptable conceptions of chemical equations and their application.

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Thinking Tasks for Undergraduate Chemistry Students

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Background to the project

At the heart of the project is the recognition that chemistry is a very complex, concept-rich area of study with an extraordinary degree of interdependence amongst the concepts and between the concepts and the “facts”. Far from being a subject that can be presented and learned in a linear sequence, even for professional chemists knowledge consists of partial understanding of each area of the field (variable from person to person, area to area) with changing number and strength of linkages between the areas. As our partial knowledge in one area advances, this allows illumination that

leads to enrichment of our partial knowledge of other areas, as well as perhaps to an increase in the number and intensity of recognised links between areas. Which in turn *ad infinitum*.

This view of learning chemistry recognises the enormity of the challenge facing teachers and, more particularly, the enormity of the challenge facing students. So much so that perhaps it is not surprising that many students learn to play the “game” of rote learning, regurgitation of definitions and key phrases without understanding, and blind use of algorithms to disguise their highly compartmentalised knowledge. The science

education research literature abounds with evidence that for many students the traditional transmission model of instruction has severe deficiencies. Gross student misconceptions have been found to be quite common, regardless of country, level of education or content area. Furthermore, research has shown time and again that conceptions — including misconceptions — are extremely resistant to change.

Largely because of the exposed deficiencies in the transmission model of instruction, instructional designers are turning to “constructivist” views of knowing and learning, which recognise the uniqueness of each person’s knowing, and how each person comes to know. According to this perspective, knowing is the individual reality that each person constructs as a result of interpreting their experiences. This project has as its basic postulate that worthwhile learning only results from a struggle to construct meaning from our experiences, in the light of previous understandings.

Over the last two decades, science education researchers have invented a range of ingenious tasks for the purpose of probing students’ understandings. Recently, attention has been drawn to the potential of such tasks as effective teaching strategies because they require students to struggle with ideas in order to create their new knowledge. These “thinking tasks” can help students to see an overview of the subject matter, to distinguish between closely related concepts, to understand better the relationships between concepts, to recognise meanings hidden by the jargon of definitions, to recognise non-examples as well as examples of a particular classification, or to understand the reasons for the steps in a laboratory procedure.

The author acknowledges that his interest in strategies that can challenge the intellect of students by requiring them to explore the subject matter in new ways was aroused by Dr Ian Mitchell in the Faculty of Education at Monash University. Strategies of this type have become a central part of the philosophies of those involved in the very successful Project for the Enhancement of Effective Learning (PEEL Project), in which Ian has been a powerful force. Most of the “thinking tasks” devised in this project are based on a comprehensive list of procedures that have been used in the PEEL Project [Mitchell, J. and Mitchell, I. (1992). *Some Classroom Procedures*. In J.R. Baird and J.R. Northfield (eds.) *Learning from the PEEL Experience*. Monash University, pp. 210-268].

The project

While it is all very well to have descriptions of these useful teaching strategies, practising teachers need specific examples ready to use or to “borrow” from. The purpose of this project was to devise a pool of “thinking tasks” appropriate to the tertiary level, mostly in the areas of aqueous solution equilibria, thermodynamics, and organic chemistry. Each task can be used “as is”, modified to suit, or to indicate how similar tasks can be constructed in other areas.

Money from the CAUT grant was used to employ a Research Officer. A large number of “thinking tasks” of many types have been created and compiled into a booklet. It is intended that a larger pool will be developed over the next few years and contributions are invited.

Types of task

The types of task created during the course of the project include all of the following, presented in alphabetical order:

- Challenging the right answer
- Completing tables
- Concept mapping
- Conversations
- Decision flowcharts
- Dirty tricks
- Flowcharts
- Incomplete lecture notes
- Inserting sub-headings in text
- Interpreting diagrams
- Linking examples to principles
- Matching outcomes with origins
- Matching the reason with the instruction
- Relational diagrams (Venn diagrams)
- Reversing the task
- Scrambled calculation steps
- Scrambled instructions
- Selecting information from grids
- Sweller questions
- What data is necessary?
- Where and why is it wrong?

The product

The tasks created during this project have been gathered together and published as *Thinking Tasks in Chemistry: Teaching for Understanding*, compiled by Bob Bucat and Todd Shand. This comprises 52 tasks in Part 1: *Equilibria in aqueous solution*, 29 tasks in Part 2: *Organic chemistry*, 35 tasks in Part 3: *Thermodynamics*, and 25 tasks in Part 4: *Miscellaneous*. It is most important that this

compilation be seen not just as a pool of tasks available for immediate use, but also as a pool of ideas that might be applicable to any topic or any concept that seems appropriate to each teacher of chemistry.

The price of the publication is AUD\$30 within Australia or AUD\$40 overseas airmail. It can be ordered from Bob Bucat, but cheques or mail orders should be made out to the Department of Chemistry, The University of Western Australia.

Development and Production of Videos for Microscale Laboratory Courses

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In 1985 Professor Mayo from Bowdoin College in the US suggested that organic chemistry practical work for students could be reduced from macroscale to microscale by altering the quantity of chemicals used from the order of 10-50 gram to 10-150 milligram. This had the advantage of reducing the cost of the chemicals, the amount of waste material produced and the cost of disposal of the waste (this latter cost is becoming significant). It also lowered the potential student and staff contact with toxic materials, essentially eliminated the risk of explosion and fire hazards and allowed experiments which were otherwise too costly and/or dangerous to be performed. Reaction times were faster allowing students to do more work more economically, and so improve their laboratory skills. Experiments which had been poorly done could even be repeated in the same practical session, thus improving the students' technique and increasing their confidence. Working on such a small scale however required special small-scale equipment to carry out the experiments.

This microscale technology was trialled at Swinburne University of Technology from 1991 and introduced into the regular course in 1993.

However, because of the small size of the microscale equipment, it was not possible to adequately demonstrate methods of assembly and manipulation of the equipment to normal sized class groups. Nor was it possible to coordinate the demonstrations at a time consistent with individual students' rate of progress and repeated demonstration to

individual students was time-consuming and detracted from demonstrator time for teaching higher order skills. A more effective, needs-based method of demonstration was considered necessary.

This project, carried out in conjunction with Dr Barry Shearer from Ballarat University where microscale work was being introduced to the chemistry course, involved the preparation of six short videos to show the various pieces of experimental apparatus and the appropriate techniques clearly. A short summary of the relevant theory for each technique was also included. The videos were made by Learning Services at Swinburne University of Technology.

The videos were made available in the laboratory for student use when and as often as required and individual students were able to view them and then execute the required techniques correctly and confidently. The students and the demonstrators reported favourably on the usefulness of the videos in the learning situation.

The main benefits in terms of student learning were the raised skill levels and improved confidence in the laboratory situation, while minimizing accidents, which resulted from repeated access to the videos when and as often as required. It also released demonstrator time for higher level work with the students in their practical classes. Thus the aims of the project were realised. This was confirmed by a more formal evaluation involving a student questionnaire and demonstrator observation.

Interactive Teaching Resources for Thermal Physics Available on the Web

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Sydney University Physics Education Research Group aims to carry out research and implement innovations in teaching in the school.

Introduction

Lectures are relatively ineffective at stimulating thought¹. The problem is that rarely is there opportunity for student participation in a way that involves their preconceptions and stimulates them to critically examine those preconceptions and, where necessary, change them. In traditional lecture rooms in science and science-related disciplines, demonstrations are the only form of interaction and are usually used to show applications of scientific theories to a passive audience. Rarely is the relationship between theory and the real world explored.

Previous work on student interaction has been done for topics like Mechanics² and Electricity³. Work has also been done on interaction using workshops and studios⁴. Little of this work is useful for our large lecture theatre environment. Resources need to be developed for interactive use in large lecture room environments.

In 1995 Fekete was employed by McInnes and Walker as part of a CAUT grant, Diagnostic Tools for Concept Development, to develop a practical and accessible database of resources to be used in a first year lecture course on Thermal Physics. The material was specifically designed for large lecture environments and included:

- information on how to use demonstrations interactively;
- a bank of questions designed to promote deeper conceptual understanding;
- references to research literature; and
- CD, film and video presentations.

The Web was chosen as the preferred option for distribution as it was the most suitable medium to disseminate information to a large international body of academics. See <http://www.physics.usyd.edu.au/teach/thermal/thermal.html>

It is a simple matter for people to print the information presented.

Particular educational problems are

addressed in the creation of this resource and include:

- **poor attention** span of students in traditionally taught lectures;
- **surface learning** approaches in students;
- **poor student motivation**;
- **preconceptions** that students bring to the subject being taught;
- the **constraints** imposed by the large theatre environment;
- the **traditional teaching styles** of academics in the school and the desire to encourage them to use interactive teaching strategies; and
- **inadequacies of assessment** methods that allow students to pass exams without understanding the concepts and their relevance to the real world⁵.

An Example

An example of one of the demonstrations available to our lecturers is shown below. It consists of a wooden box with two chimneys. Below one chimney is a candle. Below the other chimney is a metal tray containing a smouldering rope which produces black smoke. The demonstration is meant to illustrate convection.



To use this demonstration interactively the lecturer could do the following:

- show the demonstration to the students and ask the class what they think will happen when only the rope is lit: the students might respond that the smoke will rise out of the chimney above the smouldering rope
- ask the students to **predict** what will happen to the smoke if the candle is now lit and to explain why they believe in that prediction. Students would be asked to write down their prediction and to discuss it with their neighbours.
- perform the demonstration: the students **observe** that the smoke now rises out of the chimney above the candle
- ask the students who did not make the correct prediction to **explain** why their answer was different from the observation. Again the students are asked to **write down** their explanations.

While this is a simple demonstration, and most students usually make the correct prediction, it serves to illustrate the method of interaction encouraged by our database. This method of student interaction is called Predict, Observe, Explain (POE)⁶.

Evaluation

Thermal Physics was lectured to three normal classes of students and an advanced class. To test the resources of the database one of the normal classes was taught interactively, the other two classes and the advanced class were taught traditionally.

Evaluation of the resources was carried out through a number of means. Approximately 10 students from each of the three normal classes were interviewed both before and after the course was taught; entry and exit quizzes were administered to all students of all classes at the start and finish of the course; student appraisal and attendance was recorded; exam performance was evaluated.

From this information we were able to show that:

- students were better able to identify the relationship between physics and the real world and showed greater conceptual understanding (interview and quizzes);
- the student questionnaire responses indicated that the lectures were enjoyable, stimulating, satisfying, challenging,

productive and thought-provoking — sustained student attendance throughout the course supported this judgement;

- the interactive style of teaching was popular with the students compared to the traditional teaching styles (course rating 4.0 out of 5.0 (best) compared to 3.5 and 3.3 for two parallel streams);
- students' performances on traditional examination questions were equivalent to previous years;
- analysis of some of the quiz answers showed that conceptual understanding of students exposed to interactive teaching improved by as much as 30%; and
- anecdotal evidence indicated that some students adopted deeper learning approaches.

Conclusion

During 1995 and 1996 a database of teaching resources, which includes demonstrations and interactive questions, suitable for use in a lecture course on Thermal Physics was developed and placed on the Web. Teachers are able to choose demonstrations and other resources that complement their teaching styles. They are also exposed to alternative approaches in teaching, in particular interactive teaching.

In the future it is hoped to extend this resource for use by undergraduate students by making it interactive. Students will be able to access the resource for themselves and also communicate to each other and the lecturer through such tools as a discussion group.

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- ⁶ L. MC. W. Liew and D. F. Treagust, "A Predict-Observe-Explain teaching sequence for learning about students' understanding of heat and expansion of liquids", *Aust. Sci. Teachers J.*, **41**(1), 1995.

An Integrated Video and Practical Program for Teaching Microscopy

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Introduction

For students of biology, mastery of the compound light microscope is probably the single most essential technical skill they must develop and use consistently throughout their training. A 1996 survey of first year biology science students at La Trobe University (conducted by us to ascertain the entry level skills of the first year trial class) indicated that 94% of the students had used a compound microscope before coming to university, but of these, 85% felt that they had had no, little or at best superficial instruction in microscopy. Furthermore, estimates of functional and procedural knowledge of microscopy technique substantially supported these findings.

In order to address this problem of skill deficiency, an intense small group teaching and learning program, using interactive video, was developed and implemented. Evaluative tools used for the program indicated not only improved knowledge of microscopy technique, but also, and more importantly, elevated manipulative skill levels.

The Program

The program focuses on the use of interactive video in small group teaching within the laboratory — a strategy adopted to maximize teacher interaction with students and akin to that used in secondary schools (important for the transition from secondary to tertiary levels of education).

The program is intended to achieve the following specific objectives:

- to instruct students in the correct use of the compound light microscope;
- to help students understand some of the basic principles of microscopy; and
- to help students learn how to solve simple problems encountered when using a microscope.

It is a fully integrated package of three video

sequences punctuated by discussion and investigative exercises encompassing the principal areas of microscope use viz.

Part One: Introduction to Microscopy

This part comprises a video sequence with associated practical exercises which serves to provoke students' interest in microscopy, explain the basics of microscopy, and introduce the fundamental concepts of magnification and resolution.

Part Two: Use of the Compound Light Microscope

A video sequence and associated laboratory exercises elaborate the major components of a compound light microscope, their function and how to correctly adjust and use the microscope.

Part Three: Trouble Shooting in Microscopy

A video sequence provides an account of three commonly encountered problems in microscopy. Each problem is presented, followed by a hiatus for group discussion to resolve the problem. A solution is subsequently presented.

The above structure was adopted such that each part can be used independent of the other parts, depending on the time allocation and the level of instruction required.

An AUSLAN (Australian Sign Language) version of the program was developed in response to the increasing number of deaf students entering tertiary education.

Evaluation and Assessment

A preliminary evaluation of the program was conducted in 1995, in a second semester, first year course. The evaluation was repeated in 1996 after implementation in first semester. Evaluation of competence levels was conducted over the semester. Essential to this evaluation

were opportunities for feedback and remedial work until students achieved a specified level of performance.

Evaluation of student competence levels comprised:

- direct observation by teaching staff — an observation checklist was compiled for each student;
- practical test under teacher supervision;
- questionnaire; and
- self-assessment.

Evaluation of the program occurred at three levels, viz.

- teaching staff,
- students,
- the project reference group, comprising discussion, interviews and questionnaires.

Results

Evaluation of Student Skills

Of the ten manipulative skills evaluated by the observation checklist, five had competency levels above 90%, and of these, four were considered 'primary skills', that is, essential for successful examination of a specimen.

Competency levels for the other five skills evaluated ranged from 53% to 73% and

diagnosed deficiencies in microscopy skill development which will require greater emphasis in future strategies for skill development and instruction.

Entry and exit skill levels for knowledge and comprehension of microscopy was determined for all students. In all of the questions posed there was a statistically significant increase in skill level (Figure 1).

The 1996 survey proved invaluable as a diagnostic tool and detected several deficiencies in the knowledge base of students. These results were in accord with the manipulative skill deficiencies exposed by the observation checklist, supporting the case for modifications to the instructional emphasis of the program.

During first semester 1996, second year students enrolled for the B.Sc. (Biological Sciences) were surveyed with the same seven questions as the 1995 first year survey to evaluate retention levels for knowledge and comprehension. A slight diminution occurred in only three questions (to 70%, 70% and 87% respectively). Improvements were noted for the other questions of the survey (Figure 2).

The program was also integrated into the new Forensic Science Post-graduate Diploma at La Trobe. The students (graduates already employed in forensic sciences) showed a significant increase in knowledge (Figure 3).

Percentage of Correct Answers to Knowledge Questions Before and After Microscopy Program

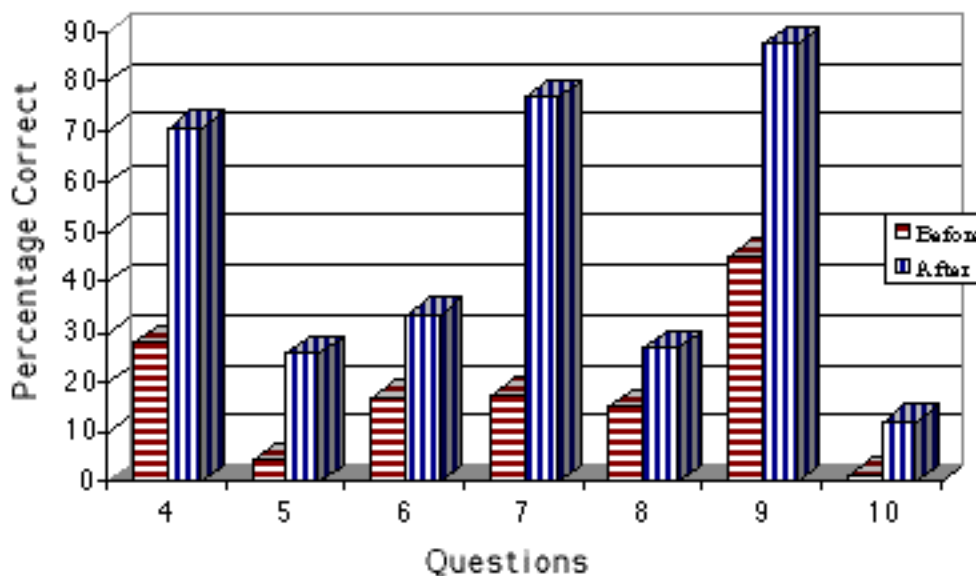


Figure 1

**Percentage of Correct Answers at End of Program
in First Year and in Second Year**

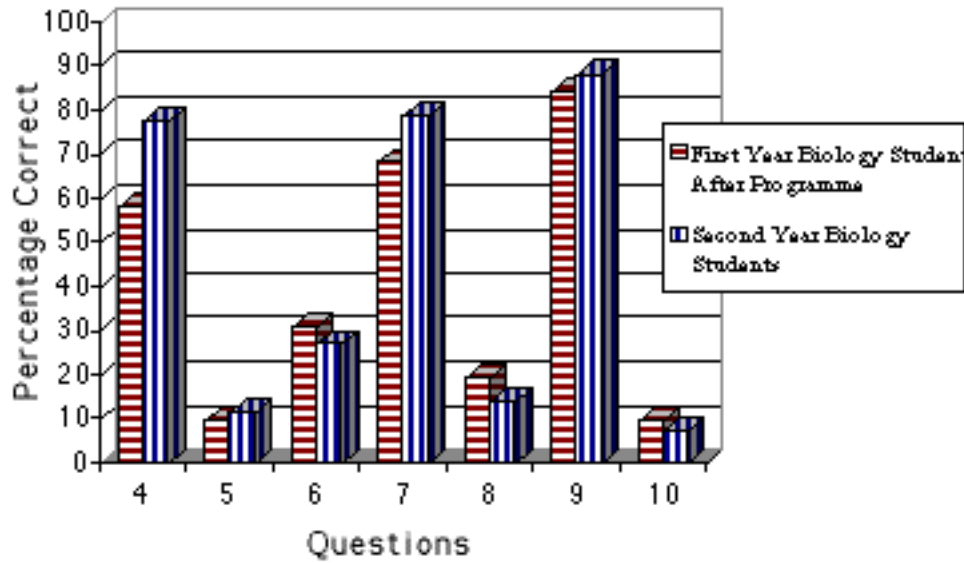


Figure 2

**Percentage of Correct Answers for Forensic
Science P.G. Students**

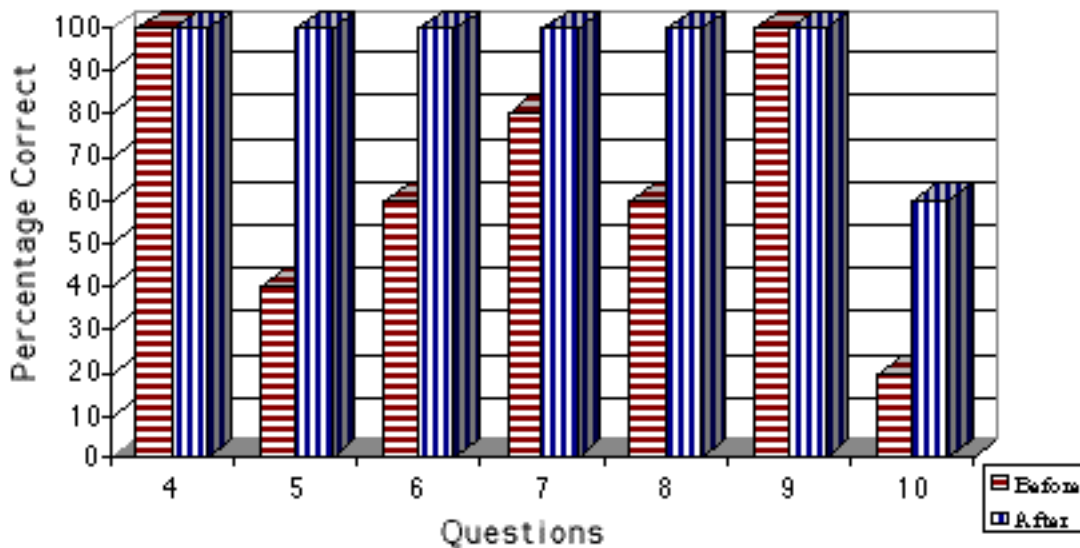


Figure 3

Evaluation of the Program

The teaching staff who participated in implementing the program endorsed the video - practical format with its attendant resource material, as an effective strategy for teaching and learning microscopy. Staff, particularly those experienced in teaching microscopy to first year students, found the checklist an effective strategy for monitoring and feedback.

All the staff supported maintaining the

program for teaching and learning microscopy.

Students participating in the program were surveyed on the palatability and effectiveness of the program. In general the students endorsed the program indicating strong support for the level of integration of the resources and the medium used, the instructional value of the print material provided and the instructional value of the feedback strategy used by the teaching staff.

Implementation

The program has been fully integrated into the core curriculum for undergraduate studies for the degree of Bachelor of Science (Biological Sciences) at La Trobe University.

A promotional flier was sent to all universities in Australia and all secondary schools and T.A.F.E. colleges in Victoria.

The program has also been promoted via a

WWW home page

<http://www.gen.latrobe.edu.au/microscopy/>

The page has been listed on the Yahoo and Alta Vista search engines and over 1,300 'hits' have been made. This has resulted in enquiries from England, Belgium, America and Australia.

The package has been sold to Victorian secondary schools and T.A.F.E.s as well as Australian universities.

Application of Explanation Based Learning to the Teaching of Biochemical Calculations

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The Problem

Enter any Biochemistry Department tea room in the world and you're likely to hear the question. "Why do so many Biochemistry students have problems with chemical calculations?". What's surprising is that the mathematics and concepts involved are as simple as those used to calculate a restaurant bill. Indeed, we think that the reason for the problem is that students treat biochemical calculations as abstract and, instead of trying to visualise the question and develop problem solving strategies, they rely on rote-learned formulae. As a result, they never develop any confidence in calculation techniques, and therefore are never in a position to judge if an answer is sensible.

The Solution

We wanted to design computer-based calculations guides containing animations which would enable students to *visualise* questions and appreciate the process by which data are obtained. We reasoned that such an approach would give students experience at reducing a seemingly long, complicated written question into a simple picture from which numbers can be hung. We planned to include as much interaction as possible so that we could teach a problem solving strategy, build

confidence, and give real-time formative feedback.

Development

Before development even started, we set up regular group discussions with tutors, students and programmers. Indeed, the project evolved in response to students' requirements.

In our original application, we asked for funds to pay an outside developer to construct the software. However, it soon became clear that, if the students were to be involved in the development of the modules, then the 'programmer' should be a competent teacher of biochemical calculations. Such is the ease with which multimedia programs can be developed using modern software (we used *Authorware*) that, in our opinion, a computer-literate Biochemist can produce Biochemical programs more efficiently than a non-Biochemist multimedia guru. In fact, our job as project leaders was made much easier by the fact that we did not have to explain the needs of the students to a non-biochemist programmer.

The Product

Four separate modules were developed: Buffers, Radioactivity, Spectrophotometry and Step-Wise Calculations.

Finally, each module contains a number of interactive quiz questions. If the student is unclear about the strategy to approach a question or how to reach the answer at any stage of each calculation, they can request on-line help.

Reflections

The programs have been well received by the students and have been used in the teaching of Biochemistry courses both here and overseas. However, although it was hoped that, by presenting the subject in an animated and dynamic manner, the computer would mimic the teaching style used by a tutor, we feel that we are a long way from a situation in which the computer *genuinely* interacts with the student and actually seeks to ascertain *why* a student made a particular mistake.

So, as well as allowing us to produce some software of which we are reasonably proud, the CAUT experience has taught us that the words

shown on our computer lab walls still ring true, "If your tutor can be replaced by a computer, they should be replaced by a teacher".

Availability

The tutorials have been made available free of charge for both Mac and DOS platforms on the WWW at

<http://www.biochem.usyd.edu.au/~gareth/sci2/sci2.html>

Acknowledgements

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- **CAL-laborate** is a collaborative publication from UniServe Science, the UK CTI centres for Physics, Chemistry and Maths and the Swedish Council for Renewal of Undergraduate Education and is available on-line
- **Proceedings of UniServe Australia Workshop** *Putting you in the picture* is available in PDF

Calendar of Coming Events

ASCILITE 97

Reflections on Learning with Technology

December 7 - 10, 1997, Perth

URL: www.curtin.edu.au/conference/ASCILITE97

email: ifyfeg@info.curtin.edu.au

UniServe Science Workshop

University Science Teaching and the Web

February 13 - 14, 1998, Sydney

URL: <http://science.uniserve.edu.au/>

email: BioSciCH@mail.usyd.edu.au

Stop Surfing - Start Teaching 1998 National Conference

Teaching and Learning Through the Internet

February 22 - 25, 1998, Myrtle Beach, South Carolina

URL: <http://web.csd.sc.edu/conted/ssst.html>

SITE 98

Society for Information Technology & Teacher Education

March 10 - 14, 1998, Washington, DC, USA

URL: <http://www.aace.org/conf/site/>

UNESCO Asia-Pacific

Education for the 21st Century in the Asia-Pacific Region

March 30 - April 3, 1998, Melbourne

URL: <http://www.dse.vic.gov.au/cis/unesconf/>

IATED 98

Computers & Advanced Technology in Education

May 27-30, 1998, Cancun, Mexico

URL: <http://www.iasted.com/cate98/cancun.html>

email: iasted@iasted.com

ED-MEDIA/ED-TELECOM 98

World conference on educational multimedia and hypermedia & World conference on educational telecommunications

June 20 - 25, 1998, Freiburg, Germany

URL: <http://www.aace.org/conf/edmedia>

email: AACE@virginia.edu

CEC 98

Chemical Education Conference: Bridging the Gap

July 2 - 6, 1998, Rockhampton

http://science.cqu.edu.au/chemistry/RACI_chem_ed_conf

email: a.lcc@cqu.edu.au

ACEC 98

Where's ITT at?

July 5 - 8, 1998, Adelaide

URL: <http://www.ozemail.com.au/~cegsa/acec98.html>

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