On-line Engineering Experiences

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Abstract: This paper describes the experiences gained through implementing on-line courses for Engineering education at Murdoch University. It describes the procedure by which the School of Engineering embarked on the process of developing its entire curriculum as suitable for web-based delivery, and the important considerations that led to a successful implementation of this strategy. It also describes both good and bad examples of web-based delivery, and suggests future developments required to further enhance the learning experience.

Background of Engineering at Murdoch

Engineering is a relatively new discipline at Murdoch University, having commenced teaching in 1996. It is located at dedicated facilities at the new Rockingham Campus, 45km to the south of the City of Perth. The new campus has been well equipped with state of the art laboratory and computing facilities.

Two engineering disciplines are currently offered: Software Engineering and Instrumentation and Control Engineering. The former programme is the only one of its type in Western Australia, while the latter is the only programme of its type in Australia. Both degrees offered are of 4 years duration, with a common first year curriculum. Both disciplines rely heavily on information technology in modern practice, and hence it was natural to consider the use of such technology not as a tool of the trade, but to assist in the learning process. One of the goals of both courses is to encourage students to use computer tools as tools of first choice, rather than purely for the more difficult engineering calculations. This philosophy has been extended to every subject, even if it is just to use a word processing package, spreadsheet, or presentation package. To assist this process, we have arranged for students to lease laptop computers under very favourable terms.

A number of other innovations have also been developed during this initial implementation phase. These include the development of an integrated Bachelor of Technology (BTech) programme whereby students can complete an Associate Diploma at the local TAFE college located on the same physical site, and then articulate to the BTech programme with full credit for their studies at the TAFE college recognised. With 1 year further study they can complete their BTech programme, and with an additional 2 years of study can then complete their Bachelor of Engineering degree. In addition, an extension programme is currently operating with 2 local high schools whereby students at these schools can study first year engineering subjects as part of their year 12 programme, and subsequently gain credit for this study upon entry into Engineering.

Being a newly established School of study, the school had very few staff (2 initially). This implied there was little "baggage" to carry, and hence the move to a new paradigm of instruction was an easier culture shift, and there was not a lot of "sunk" infrastructure in available course materials to overturn. Indeed every course was being written and delivered for the first time.

There was also a strong desire to run with a lean staffing structure. One of the ways to implement this strategy was to ensure that courses were developed by individuals, but "owned" by the School. This necessitated courses being developed in such a way that any other member of staff could easily teach any other subject by using well established and documented course material. An on-line approach enhanced this process.

Important Issues

When embarking on the process of developing whole degree programmes suitable for on-line delivery a number of very important factors must be in place.

Importance of Instructional Design and Programming Help
Instructional design is itself a skill and to expect that domain experts should also possess such knowledge is unrealistic. It is also an emerging skill to design for on-line delivery as opposed to the more traditional paper-based delivery. People with such skills are still hard to find. Similarly, it is also unrealistic to expect domain experts to be fully conversant with the intricacies of HTML coding except for making obvious links through the many WYSIWYG editors that are now available. It is by creating a team that includes as much expertise as possible – domain, instructional design, and programming skill – that successful outcomes have been achieved in this project.

Importance of resources – monetary, physical and human
The availability of such expertise is not without considerable monetary cost. Also required is the necessary infrastructure to develop and deploy such technology. We were fortunate that Murdoch University had committed itself to on-line delivery and the availability of seed finance. We were also in the unique position of not having "sunk capital" in past course development and were committed to developing new course material in any case. Thus, there was already available money to support this initiative.

Web Delivery – Good

In implementing this development, we have identified a number of factors that we believe are essential to create a good learning environment for students. We do not claim that we have mastered all of these factors ourselves, but have at least clarified some of these issues.

Easy navigation
One of the key factors that we believe has led to some success of our on-line units has been the development of an easy-to-navigate interface. We have developed two approaches to meet this objective. The first involves the use of frames to provide a static navigation aid always displayed to the student, while the other frame presents changing material. This permanent display of navigation material, shown in Figure 1, has allowed students to always have quick access to key information. In this design the course content is presented in the main frame through linked web pages and the left navigation frame provides a static set of navigation links. The student has direct access to a full range of support information (help, guidelines, assessment, rules and regulations and so on) from anywhere in the course. Within this paradigm, the material has been structured according to a fixed timetable of presentation to the student; i.e. the sequence of study is built integrally into the organization of the web pages.

A second initiative has developed a structure that is more course-concept driven – presenting the material according to key subject area concepts and providing navigation in the form of a concept map. This is shown in Figure 2. This strategy is still being trialed, but initial student reaction has been positive.

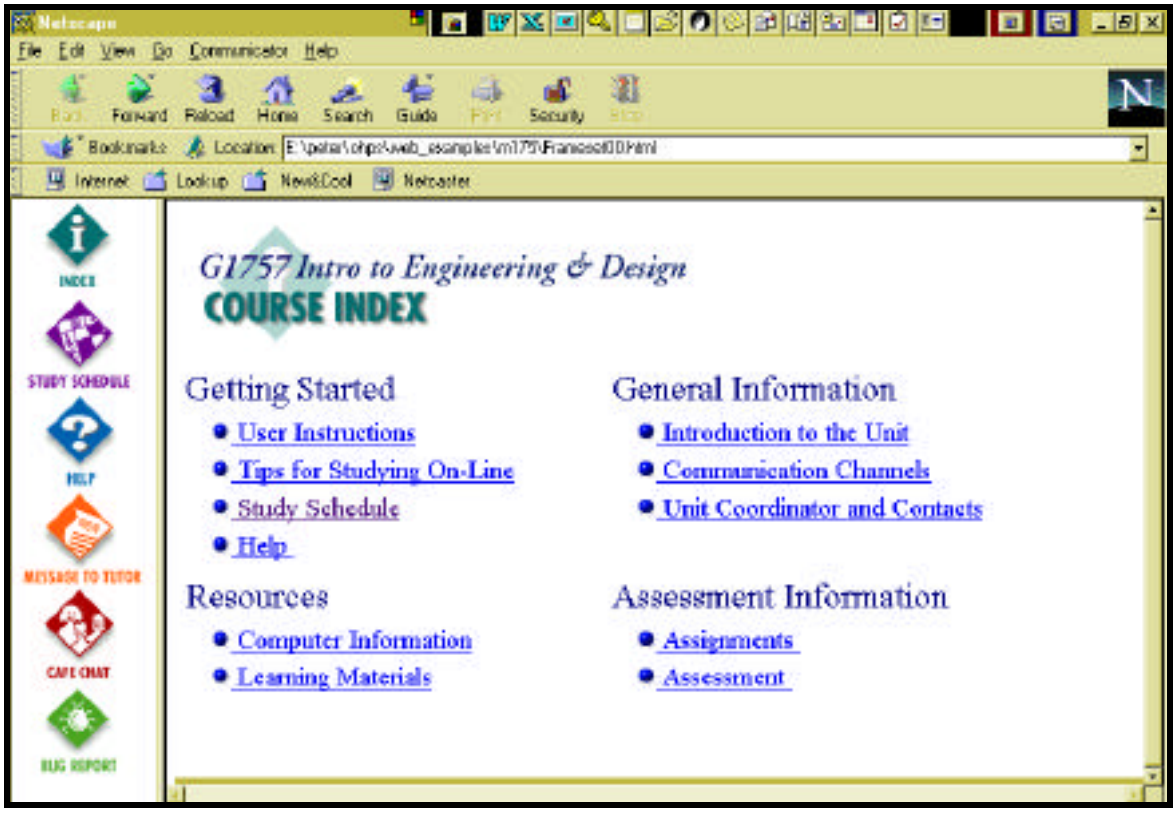

Figure 1. Navigation Aids

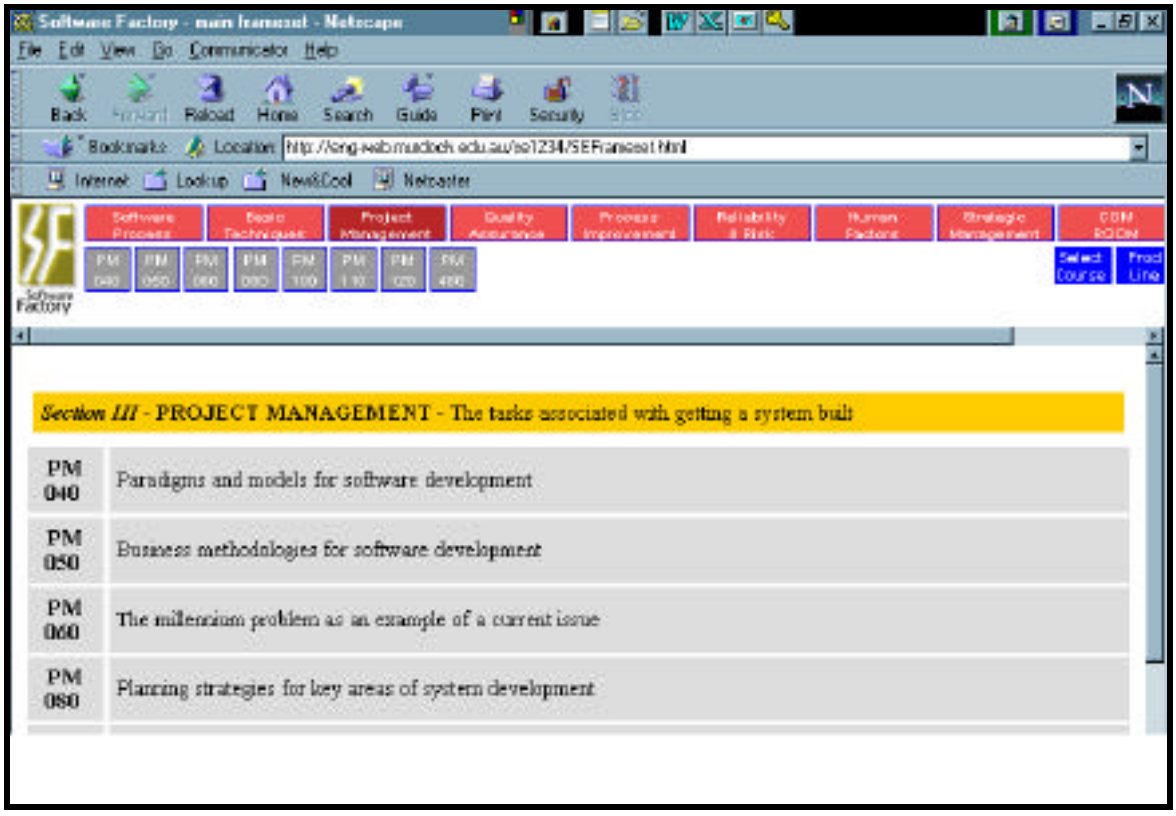

Figure 2. Content Driven Navigation

Multi-threaded

The technology also promotes the use of multiple threads. Such techniques allow students to explore material in any order that makes sense to their learning style. The use of cross-indexing and forward and backward referencing has proven to enhance student engagement with the material.

We are now experimenting with the "road map" as shown in Figure 3. In this facility students are provided with a pathway (and alternative pathways) for proceeding with their studies. They begin at the start (green node) and end at the stop (red) node. Required (blue), desirable (yellow) and suggested (green) pathways are colour coded to guide the student through the course of study.

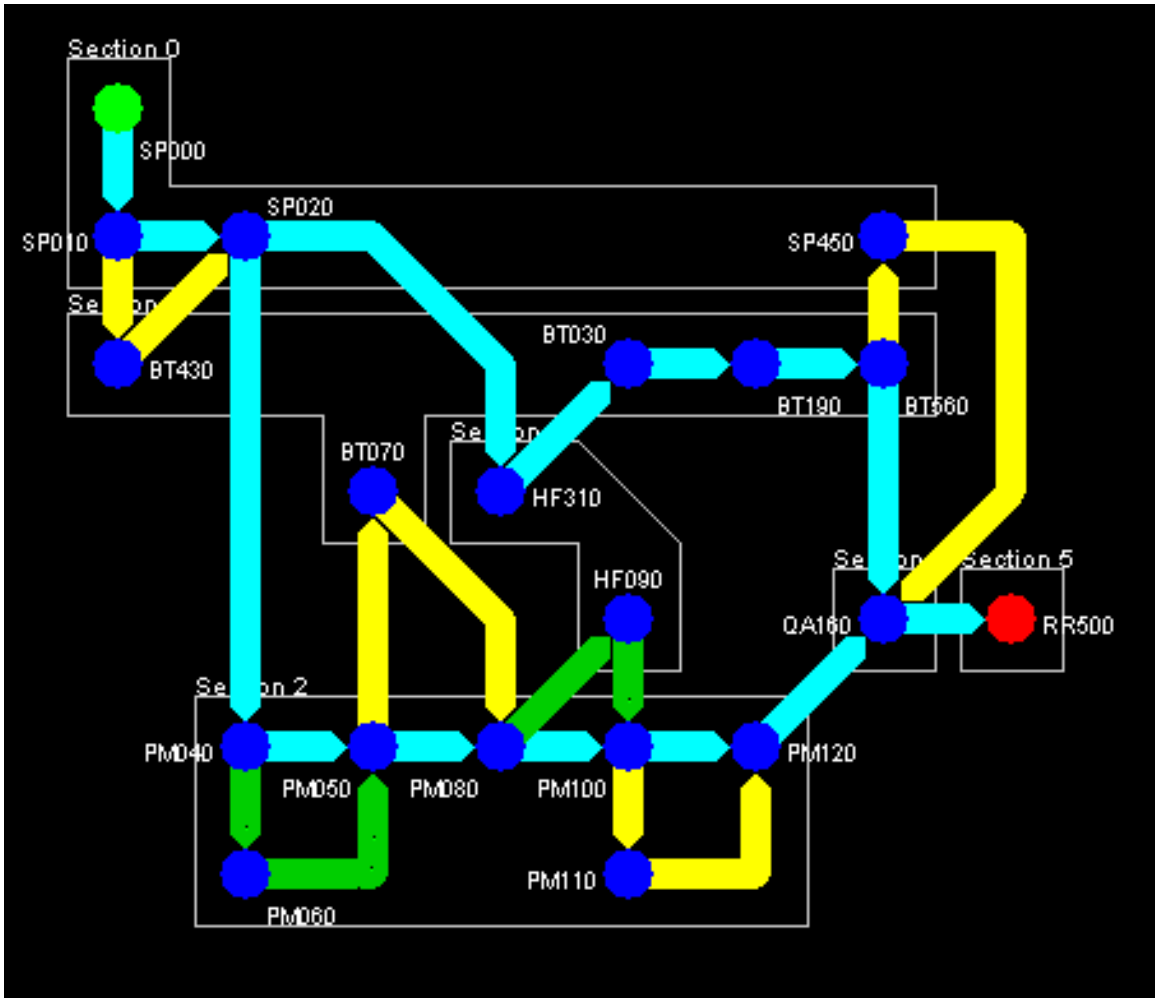

Figure 3. The Study Road map

Each node in the road map matches a study Topic as clustered into the Section classifications as shown earlier in Figure 2. Naturally, clicking on any node takes the student directly to that web page group.

Interactive

If the medium of on-line delivery is to reach its full potential, it must exploit the inherent interactivity available. We have attempted to pursue this by the use of Java applets, and by linking into the web browser existing software including *Matlab, LabView* and other programs. We also made use of existing commercial courseware and integrated that with our own web material. Our colleagues in Mathematics are utilizing "Scientific Workplace", an environment that enhances the teaching of calculus via symbolic computation. One use of a Java applet is to demonstrate sorting algorithms, as shown in Figure 4. Another example in Figure 5 shows a *Matlab* program being executed from the web page.

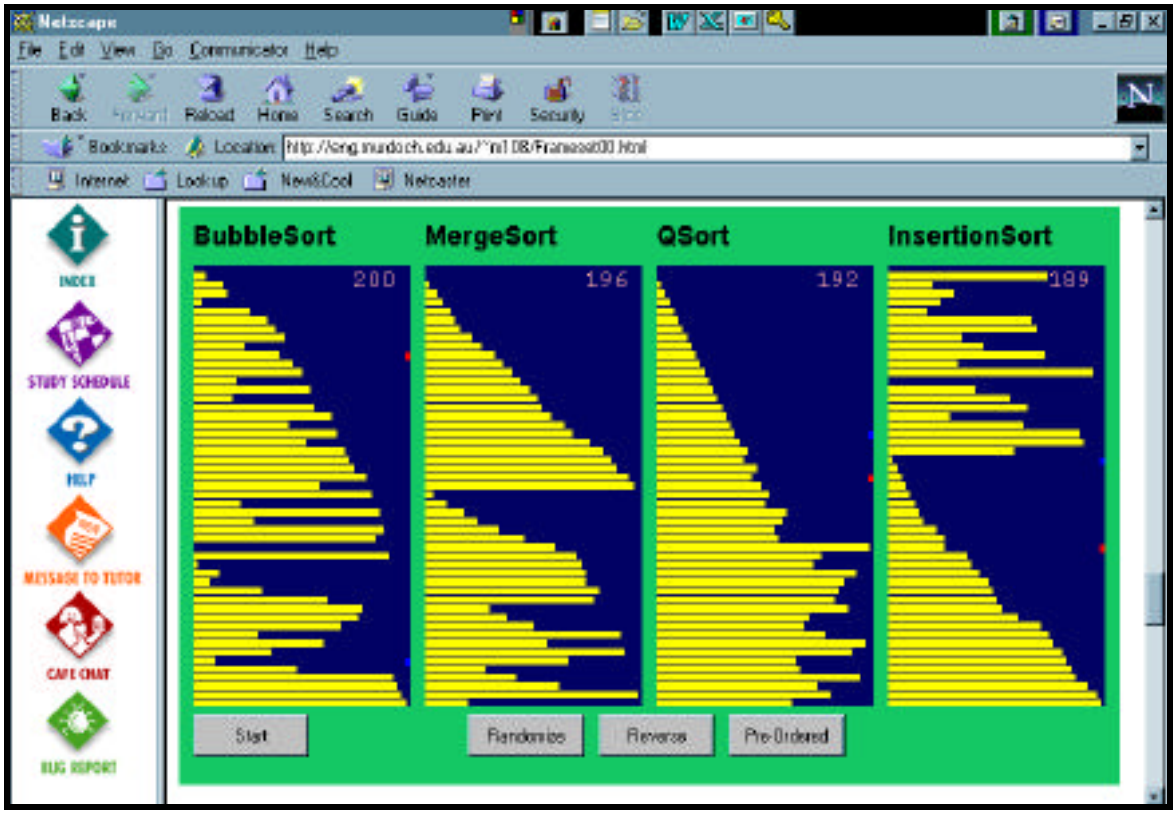

Figure 4. A Visualization of Sorting Algorithms included in the web page

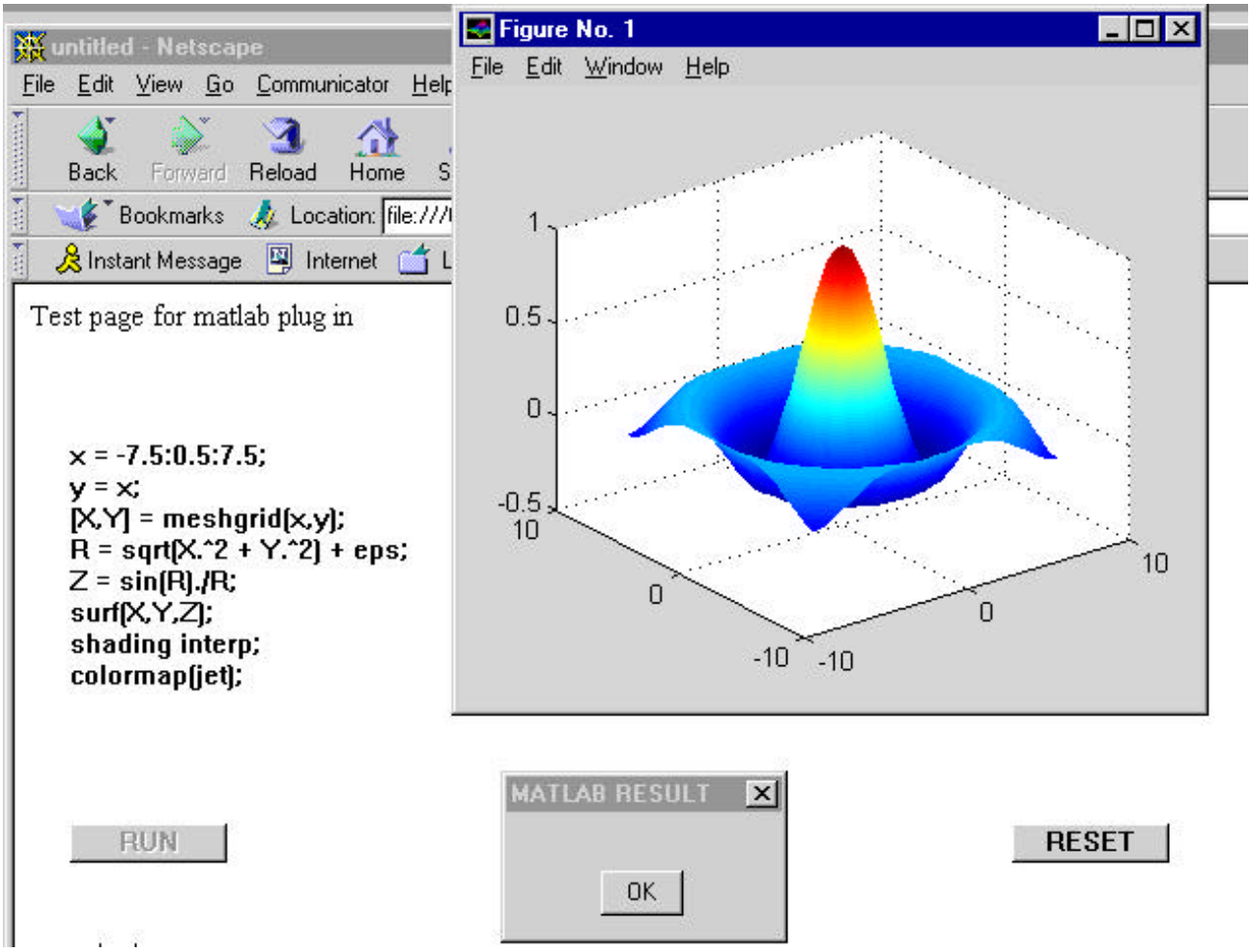

Figure 5. Executing a *Matlab* Program from the web page

Enriching
The material should also enrich the learning experience. Links to other web sites can create great student interest in the material they are studying. The recognition that there existed "real" people behind the developments that they are seeking to understand has enriched students' learning experience. This is helping to change the culture of engineering education, important in producing the next generation of engineers. It is also interesting to observe that female students tend to appreciate this approach more than their male counterparts.

Web Delivery - Bad and Ugly

From our experience there are a number of features that lead to very poor web-based teaching structures. Our pet hates include:

Scanned Word and *Acrobat* files
The technology should not be used to just scan existing paper-based notes, add a few links here and there and say that you now have an on-line course. While this may be a convenient way of distributing some lecture notes, it does not in our opinion constitute web-based teaching. It exhibits none of the features described in the previous section. We acknowledge that used sparingly to deliver background-reading material, it has a limited place.

Text documents by themselves do not make an appropriate basis for good quality web pages in teaching. There are some golden rules: viz:

- A single page to be read should be quite short, perhaps no more than 5 paragraphs
- Diagrams and graphics should be used to enhance explanations
- Students should be engaged by interactive tasks, i.e. tasks for them to do which require some thought, some action and some experimentation
- Tasks should be set to test understanding, to encourage re-reading of pages and re-working of examples.

"Where am I?" Syndrome, or "Lost in Web-space"
Our second concern is that many designs lead students to places far beyond where they started. This may be fine, but there must be a clear trail back to the point of departure, and clear indications at all times of where they are in a concept map of material. Web pages can (and do) become complex sets of documents with many complex interlinks. Some of these are in place to guide study, others to enhance study (e.g. pointing to ancillary readings and related web sites). At all times the students must feel in control of where they are at, where they have come from and where they expect to go next.

Poor Quality Design
The quality of the graphics and the design of the web pages plays an important role in convincing students that we are serious in the new approach to teaching. Particular attention must be paid to careful use of colour, preparation of graphics (diagrams and other images), and, most importantly, spelling, grammar and the general quality of the written text.

Future Directions

There are a number of issues still to be addressed in our implementation of our on-line courses. We highlight some of these issues here so that others may also be inspired to solve these problems.

Progress Tracking
Keeping track of student progress is not as easy as it first seems in an open browser environment. We have developed a prototype that uses a database residing on the server computer but still requires

the student to manually record their progress in the database. We have constructed a browser interface for both the students and lecturing staff to monitor and analyse progression rates. An image of the student record screen is shown in Figure 6. Here we see the current state of user "geoff", showing what parts of the course are complete, in progress and yet to be attempted. A detail of the chart is shown in Figure 7.

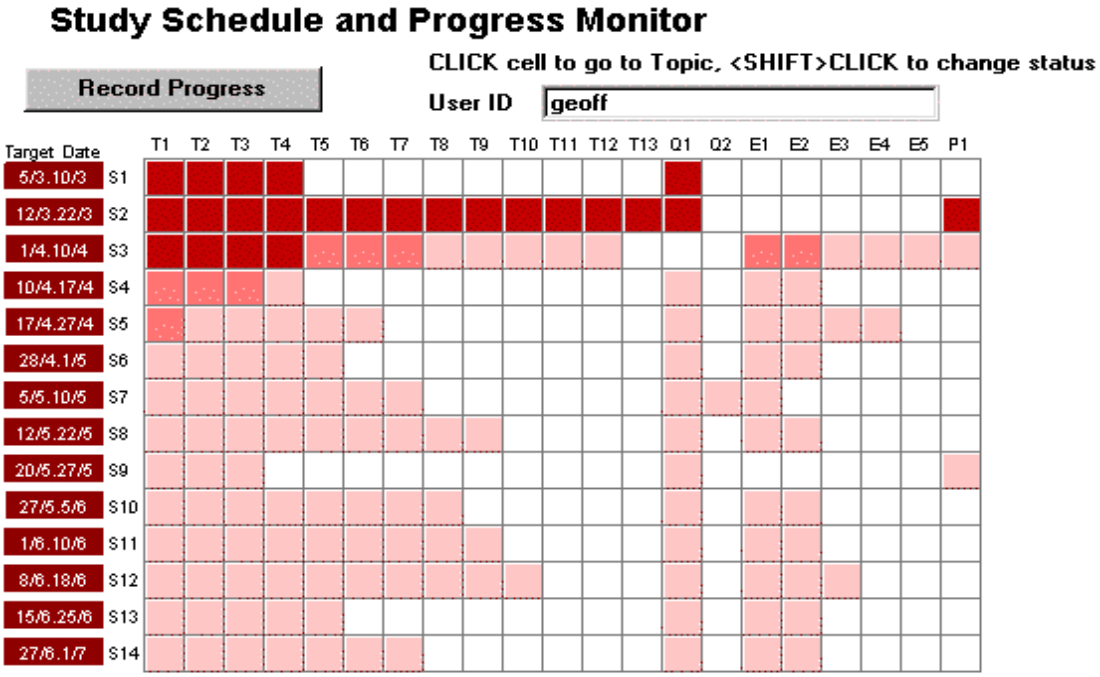

Figure 6. The Study Schedule Planner and Progress Monitor

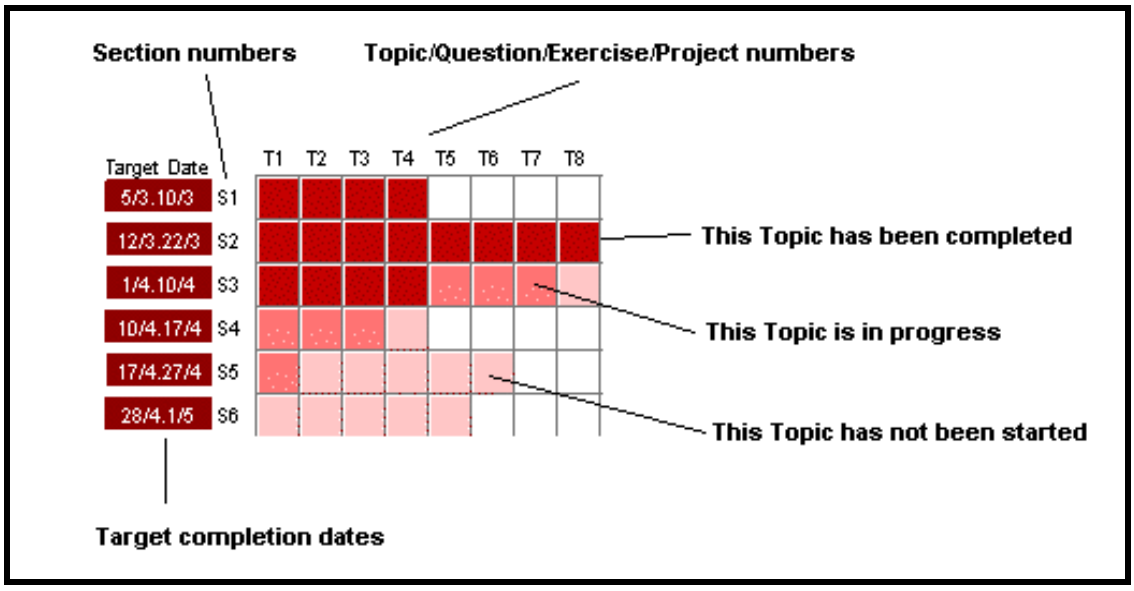

Figure 7. Detail Study Schedule Planner and Progress Monitor

A system that automatically tracked a student's progress through the material, and even diagnosed that the student required extra tuition or could progress faster would be very useful. Such a system would enter into the world of intelligent tutoring systems, an area of very active research.

Electronic Submission and Marking

The problem of receiving student submission of assignments and returning marked versions to students is still not solved technically. Issues seem to revolve around ensuring that submissions received originate from the student in question, and not submitted from elsewhere.

Electronic Whiteboard

The use of electronic whiteboards, whereby a lecturer could use a writing tablet in one location and have the image displayed to a number of students in other locations and vice versa still does not seem to be straight forward – at least in an open browser environment. The advantages of such interactivity to display equation development and problem solving strategies are obvious.

Remotely Operated Experiment

One of the key challenges to address will be the role of experimentation. "Dry" laboratories or computer-based simulations do not provide the full rich learning experience of laboratory experiments. Operating some experiments over the web is possible but the communications bandwidth available and the safety issues involved currently limit the scope of such activities. The future may solve the former, but is unlikely to solve the latter.

Student Response

We have had one year's experience with web-based teaching and the feed back we have from students is very encouraging. We can say that we are doing at least as well as more traditional methods with some indications that it may be better. Some particular responses from students include:

- Positive support to having course materials available any time, and especially from home.
- Reduction in numbers of formal lectures
- An appreciation that the quality of the web-based materials is supportive of a productive study programme

Acknowledgments

The authors wish to acknowledge a number of people who have contributed to the development of Murdoch University's Engineering School on-line delivery units. In particular, the work of Romana Pospisil who contributed much to the initial template design, Nick Nelisen who contributed much of the code to implement the vision, other colleagues within the Engineering School and within the Academic Service Unit are all gratefully acknowledged.