The teaching of discrete mathematics is an important part of the undergraduate computing curriculum. It is used to introduce students to a number of theoretical issues in computer science, and also to teach skills and knowledge that they need in other parts of their courses [5]. At UCLAN discrete mathematics is taught as part of a module called “Problem Solving”. This module is delivered to all the first year undergraduates whether they are doing degree, foundation degree or HND courses.

The experience of the lecturers teaching on this module is that every year a fair number of first year students express dismay at having to study maths “again”. The reasons for this negative response vary, but are often that students feel maths is not core to their learning experience, that they came to university to study computing not maths, that they haven’t done maths for ages and have (happily) forgotten much of it, and anyway, how is it relevant to computing?

This negativity has caused problems with the teaching of the subject, particularly since a number of students arrive with fairly weak maths skills. We have noticed that there is often a link between students’ self-perception of their maths ability and their attitude towards the module. Students who perceive themselves to have weak maths skills are reluctant to spend as much time as necessary to improve, and consequently often score poorly in the end of year tests. Other studies show that negative student attitudes towards maths are reflected by poor results [3], [6].

The author and her colleagues have undertaken the work described in this article over the last 5 years of teaching this module. The aim has been to improve the way that the students engage with the subject, to increase the time they spend studying maths on their own, and hence to encourage a more positive attitude towards the learning of mathematics [7]. The principle behind the project was that reflective practice to consolidate learning is vital to students’ success in mathematics [1], [2]. The theoretical basis for this is a constructivist approach to learning [8]. Once the students have been formally introduced to new concepts they need time to assimilate and digest the ideas so that they can fit them into their own internal model. Having had a chance to do this, they also need an opportunity to practice applying the concepts in new situations.

It was never envisaged that one technique or idea would solve these problems, rather a series of ideas have been implemented over the years. Some of the ideas are linked together whereas others stand on their own. The technical focus has centred on the use of WebCT as this is the managed learning environment that has been implemented over the whole university and all module leaders are encouraged to use it. The WebCT site developed by the course leader has been used as a central repository for all the module material, with on-line practical material, on-line multiple-choice tests and a discussion forum, as well as links to lecture and tutorial notes.

The Attitude Survey

Understanding what motivates students is particularly important when you’re required to stand in front of 140 first year computing students to persuade them that spending the next year learning about predicate logic, binary trees and...
set theory will be useful and fun. One of the first things we did was to conduct an attitude survey in conjunction with a maths test, to see what sort of skill range students were coming in with, what attitude they had to learning maths and how their views changed over the course of the first year. The survey was run in the early years of the module development, from 1999 to 2001, by means of a questionnaire that was given out to students at the beginning of the module and again at the end.

Students come into our courses with a wide variety of previous maths skills, from those who have taken several attempts to get a bare pass at GCSE (or equivalent) to those who have attained good grades at ‘A’ level. At the beginning of 2000/01 71% of incoming students stated the intention of spending time improving their maths during the year, at the end of the module 62% said they felt they had achieved this goal. Despite the drop, this indicated satisfactory student effort. Results also indicated that 68% of the students had enjoyed using the computers for doing maths. This was quite a high percentage, and showed a positive attitude towards using technology as part of the maths curriculum for this particular set of students.

However when looking at underlying attitude and self-perceptions, the indications were that these did not basically change over the year. For example, results from the academic year 2000/2001 show that when asked whether they liked or disliked maths more than at the beginning of the course, 70% of the Degree students and 80% of the HND students stated that their attitude to maths had not changed. The students were also asked to self-rate their maths ability, both at the beginning and at the end of the module, using a scale from 0 (terrible) to 5 (very good). Although the average self-rating score for the Degree students went down slightly from 3.1 to 2.8 over the course of the year, and for the HND students it went up slightly from 2.9 to 3.0, these shifts were not significant. This information provided a useful insight alongside all the positive feedback about the new experimental parts of the module, namely that students had fairly fixed underlying perceptions about how good/bad they were at maths and that these perceptions were difficult to shift.

**Building web pages**

One of the observations that we’d made was that our computing students like to spend time in the labs doing practical work on the computers. This was the spur for the idea of getting the students to build web pages to describe how to solve certain types of maths problems and to illustrate common mistakes through the use of worked examples. An essential part of this idea was to direct students away from a passive role in maths learning.

Students involved in this part of the project developed web pages collaboratively to support the learning and practice of foundation maths skills. The four stages of Kolb’s experiential learning theory: concrete experience, reflective observation, abstract conceptualisation and active experimentation [4], were used as a theoretical starting point. This exercise started with the students being given a tutorial sheet that they had to work through. Once they had completed the questions they were given the answers and asked to look particularly at the questions that they had got wrong. They then had to analyse their answers and identify what mistakes they had made. Working in groups and discussing their different results, the questions were then used to build worked examples and to construct advice for other students on how to avoid these mistakes.

Following this process the students were asked to develop some informative and interesting web pages to illustrate what they had learned. The students used an outline web page template to help them get going quickly, but they were encouraged to individualise their pages, which almost all of them did. Most of the students took up the challenge of working in an active way as part of this project. Another positive aspect of this was that students were encouraged to work together and discuss their work. When completed, the web pages were put up on WebCT and formed a part of the web site for the Problem Solving module.

When this idea was first tried out, the students were not learning web-page development in any of their first-year modules, so this was an opportunity for them to learn about and experiment with web page implementation. However the first year curriculum has since changed and now all first-years study a module in web-page development. Since this change has occurred students have been less interested in this exercise. With the novelty value gone, this particular exercise has not been used again, but the JavaScript exercise described in the next section has continued to be used.

**Writing JavaScript programs**

Following on from the web page development work, an exercise was developed in semester two in which students were asked to build interactive web pages that automated some of the concepts they had been learning. Students were introduced to JavaScript programming and they worked in groups to write some interactive web pages. They were asked to work on problems such as fractional arithmetic, prime factorizing integers, set
manipulations and propositional logic.

Since algorithm design and pseudocode were part of the semester two syllabus for the module, this gave students an opportunity to put some of their ideas into practice in an easy-to-use environment. The instant results and the ease with which code can be embedded alongside text were positive factors for the students. However, programming in JavaScript can be frustrating as it is a weakly typed language and requires extra care when programming numerical manipulations. Nevertheless this has remained a useful exercise for students and it has been used with every cohort.

Problem of the week

Instead of putting all the course materials up on the WebCT at the beginning of the year, each week’s lecture and tutorial notes were put up at the beginning of the week to encourage students to look at the site regularly and work on the current week’s material. As part of this move to get students to look at the site regularly, the Problem of the Week was introduced in order to encourage students to think about problems in their own time and to use the WebCT discussion list to propose and discuss possible solutions.

Each week the tutor posted a new problem up on the discussion board and students were encouraged to post their answers or thoughts in response to the question. The questions set were fairly easy at the beginning of the year and were made progressively harder. A prize of a bar of chocolate was given out to the first student to post the correct answer to the question on the WebCT discussion list. Unanswered questions stayed up until a correct answer was given. On average about 40% of the group in each year have been active in posting answers to the Problem of the Week questions, and many of these students have access the WebCT site from home in their own time in order to post answers. The group of students to whom it appeals is not just the strong students (although it clearly appeals to these students as well); it seems that some students just like a challenge. Additionally the Problem of the Week has generated discussion and friendly banter in the tutorials and so has had a positive effect on group dynamics.

Conclusions

Overall the exercises have all had positive outcomes. Many students have said that discussing maths is helpful to them as a learning strategy, and the thread that links all these exercises is an attempt to engage students in conversations about maths. Feedback from the questionnaire indicates that students rate small group discussion as the most effective way of learning maths and this has been backed up by observational evidence. Ideas for the future are to increase the opportunity for students to work at different levels and to give them more choice. In order to maintain motivation, students need to be challenged by the work that they are set. With groups of mixed abilities this means that students may have to be working at different levels in order to maintain their motivation.

References