For a number of years, the acoustics section within the School of Computing, Science and Engineering at the University of Salford experienced unacceptable failure rates in mathematics at level 1. This paper describes and reflects on wide-ranging changes that we have introduced which have seen an increase in the number of students passing level 1 mathematics, without the need to resit, from only 52% (prior to the changes) to 96% (in 2005). During this time there have been no changes in our entry requirements or profile.

Widening participation

In common with other Universities in 2002 the University of Salford received a grant to support widening participation. The University invited Schools to submit bids to conduct work targeting aspects of widening participation within individual Schools.

The acoustics section bid for funding to allow one of the authors (D John Martin) to be employed for two years on a half time basis to focus on mathematics working with the staff involved in the module. The funding also allowed for some postgraduate and secretarial support and travel.

Beliefs and approach

The work was influenced by several factors that were important in the context of the development and the approach of the staff involved. Some of these were clear from the outset; others emerged as we discussed the issues with colleagues from other Universities. The most significant were:

- The extra staffing would only be available for a limited period. It was therefore essential that, whatever changes were made, they would not significantly increase the staff time required once the extra funding had ceased.
- In the early stages we believed that falling standards in ‘A’ level mathematics [1] might be the cause of our low pass rates. By surveys and small group discussions, we came to the conclusion that this was not our central problem but that many of our students without ‘A’ level mathematics, but with a ‘numerate science’ (about 40%), became overwhelmed and disillusioned at an early stage of the module, and a significant number of those with ‘A’ level mathematics got the message at an early stage that they ‘knew it all’, did not attend and missed key later material.
- It was therefore important to develop an approach that supported those without ‘A’ level, simultaneously challenged those with ‘A’ level, and did this in a way that was economic with staff time – hence the title of this article. Varied approaches to the key areas of mathematics involved were needed, together with small group and individual support where needed.
- We felt it was important to share with students our concern with the previous arrangements, the reasons why we were making changes and to seek their views on the effectiveness of these by regular small group interviews and questionnaires.
- We regarded it as a high priority to develop means whereby students could be encouraged into, and rewarded for, working consistently,
given formative feedback on their progress and timely support.
- We believed that students who were struggling with mathematics would be doubly disadvantaged if they were required to copy notes during lectures; we suspected that the notes would be incomplete and inaccurate, and would serve them poorly in after-lecture study.
- In our experience, many students in engineering and science do not realise the importance of mathematics for professional practice. We therefore felt it was essential to enable them to appreciate the applications of mathematics to acoustics at all stages.
- The work would have been impossible without the willingness of the senior management in the acoustics section and the School to allow us to rapidly try a range of significant changes.
- We felt it was important to learn from the positive experience of other Universities tackling similar problems by attending and participating in all relevant meetings, studying pertinent literature and visiting other Universities.
- D John Martin had previously acted as course leader on a degree involving extensive group-based projects [2] and was keen to use this experience to develop a system of peer support among the students.

What mathematics do our students need?

An obvious ‘solution’ to low pass rates is to reduce expectations. Of course, if the result is that graduates lack key knowledge required for effective professional practice, this is counterproductive.

At an early stage in the development we therefore conducted a survey of 41 industry contacts to seek their views of the areas of mathematics that were important for our students. We found that the broad consensus of industry colleagues aligned well with our existing syllabus. We also reviewed with our second-year and third-year lecturers what mathematical elements were considered essential for teaching their courses.

One aspect of mathematics that was absent from our level 1 syllabus, but regarded as important by many in industry, was statistics and probability. We made the decision that at the present time we would not attempt to add further material to the module, since the likely consequence would be even lower pass rates.

An important spin-off of this study was that we are able to share with our students the views of industry colleagues on the importance of mathematics.

Key changes

In the process of consulting students, academic staff and industry we tried several changes that we later judged to be less helpful and that we later abandoned.

In earlier years the module had been organised as two hours of lectures per week with a one hour problem-solving tutorial every second week and an examination at the end of each semester. Students were required to take a diagnostic mathematics test – developed by Coventry University and administered online by the University of Salford’s mathematics support centre (MathScope [3]) during induction week and encouraged to make use of the centre if they were experiencing difficulties. Unfortunately the use made of this service was low.

In the revised system the pattern of two hours of lectures per week was retained. However, the style of these was radically changed. To address the problem of note taking in lectures we now use the Workbooks appropriate for our module produced by the HELM [4] project. These consist of self-study material on focussed topics with extensive exercises. The HELM materials are available free to England and Northern Ireland HE providers and have been of major benefit to us:

- The lectures now focus on elucidating key issues in the Workbooks – it is not necessary to cover every detail.
- Because the booklets are printed in-house, we are able to incorporate exercises that require the students to apply the mathematics that they are learning to situation in acoustics and related areas. Some questions of this type are also used in assessment. We think this relevance to the students’ subject of interest is a key element because it brings the maths much more alive and connects to their other concurrent lectures.
- In addition, we have produced worked solutions to about half the relevant HELM exercises.
- The HELM workbooks have enabled students to take a greater ownership of their own learning. We believe that promoting scholarliness and the concept of student centred learning – where possible – will help students pass the module and better equip them for level 2 and 3.

The tutorials have been reorganised. Tutorials are now held every week, and the 70 students divided into two groups, based on their scores in the diagnostic test. This
allows the tutors to tune the level and pace of the tutorials to the needs of the students. The ‘advanced’ group is deliberately challenged to some extent, so that the interest of the better prepared students is retained. For example, they are introduced at an early stage to Matlab [5] software and encouraged to use this to look at acoustics exercises. The new pattern of the tutorials is that the students work on examples and the staff circulate and discuss issues with students.

Based on our belief in the importance of formative feedback and rewarding students for working consistently throughout the module, we have evolved a system of phase tests that simultaneously provides both formative and summative assessment. Every half-semester the students take a test based on the material in the HELM workbooks from the previous six weeks. To reduce the demand on staff time the format of the questions and the marks scheme are short and simple. In that way the administration and marking can be undertaken by postgraduate students.

The system provides summative assessment because the students know that if they achieve the pass mark for a phase test they will not be required to do the corresponding section of the end of module examination. It is formative in that they are given model answers immediately after the test and their marks within a day. They are required to attend the University maths centre at least three times if they have not passed the phase test. Attendance at the centre has increased dramatically.

The HELM Project has produced a large bank of online multiple-choice questions and using these, plus a small number of examples that we have generated on applications in acoustics, we have produced what we call practice phase tests that the students use extensively prior to phase tests.

We have developed a small web site to support the module. One feature of this is links to online lectures [6].

A quite radical departure from previous teaching at first year was our introduction of a group assignment. This had a number of objectives. Firstly, we were keen to promote discussion about mathematics between the students. Secondly, we structure the assignment to provide peer support by ensuring (based on the diagnostic test) that each group has stronger and weaker students. Our intention is that this peer support will be helpful with the module as a whole, not just the assignment. Thirdly, the assignment is based on an investigation into and oral presentation of an aspect of acoustics, and the ways in which mathematics is relevant to this – further underlining the issue of relevance. We were particularly impressed with the overall quality of the presentations by the students.

Attendance is now recorded at lectures and tutorials, and students contacted if they are consistently absent.

We also believe that, especially for students who lack confidence and experience, a friendly, positive and encouraging approach by staff is essential.

**Student views**

Early in semester 1 of 2005 a questionnaire survey of a group of 29 level 2 students was undertaken, asking them to rate how useful they had found the changes described above in helping them with the first year mathematics module. They were asked to rate each aspect on a four-point Likert scale [7]. Fig 1 shows the modal responses. All aspects were valued, with the worked solutions, the option to retake just the relevant section of the exam if they had not passed a phase test and the support of the University maths centre (34% of the students surveyed had made use of the centre) being most strongly appreciated.

Though students rated the group assignment lowest, staff believe that the assignment was important in involving students in discussing mathematics and acoustics and peer support.

The students were also enthusiastic (last row) about the proposed use of more advanced HELM workbooks in level 2 and 3 modules.

![Fig 1 Modal responses used to collect student view](image-url)
References

[3] University of Salford maths centre: www.mathscope.salford.ac.uk
[6] Online mathematics lectures: www.mathcentre.ac.uk
[7] Likert scale: www.icbl.hw.ac.uk/ltdi/cookbook/info_likert_scale

MSOR News

Queen’s Anniversary Prize

The Millennium Mathematics Project has been awarded a Queen’s Anniversary Prize for Higher and Further Education. This is the highest award for achievement in the higher and further education sector and is the educational and research counterpart of the Queen’s Awards for Industry.

The Millennium Mathematics Project (MMP) was launched in 1999 as a joint project between the Faculties of Mathematics and Education at the University of Cambridge. The aim of the project is to support mathematics education in primary and secondary schools throughout the UK and promote the development of mathematical skills and understanding, particularly through enrichment and extension activities beyond the school curriculum, and through activities designed to increase the mathematical understanding of the general public.

The project’s activities have a significant regional, national and international impact, and MMP resources have been repeatedly commended by the Department for Education and Skills.

Professor John D Barrow FRS, the Director of the Millennium Mathematics Project, said: ‘I am delighted that the Millennium Mathematics Project has been awarded the Queen’s Anniversary Prize. This is a tribute to the vision of those in the University who initiated this project, those in the outside world who added their support for it, and all the members of our dedicated Project team who have made such a wide-ranging impact in schools and amongst the general public. This Prize is also a welcome confirmation of the vital importance of mathematics to the United Kingdom.’

The Queen’s Anniversary Prizes recognise and honour outstanding achievement and excellence at world-class level in UK universities and colleges. All universities and colleges across the UK are invited to make a single entry in each biennial round. Entries must demonstrate outstanding achievement and benefit brought to the institution and the wider community, and the Awards Council look in particular for signs of initiative, innovation and originality.

Uniquely in the field of education, these Prizes sit within the national honours system. Names of Prize-winners are put forward to the Prime Minister, who advises the Queen and seeks her assent. The formal presentation of the Prize medal by Her Majesty the Queen will take place at Buckingham Palace on 16 February 2006.