

Approaches to Teaching for Engineering and Science

Teaching Students with Diverse Backgrounds

Teaching Mathematics to First Year Engineering Students with a Wide Range of Mathematical Ability

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Abstract

The approach to teaching Maths to Year 1 students in the Department of Engineering underwent a major reorganisation prior to the start of the 2002/3 session. The aim was to provide an optimum framework within which students studying four different engineering disciplines could be taught Maths within the resource constraints imposed by student numbers, and to cope with the extremely wide range of their Mathematical abilities on entry to these degree programmes. After much discussion, students are now taught their Year 1 Maths topics in two different cohorts, streamed according to initial Maths ability, and using different approaches in terms of the depth of understanding expected. This also involves the use of different assessments. This approach has been much more popular and created far fewer difficulties than the previous system which divided the students into two groups according to degree programme.

Level of Material: First Year

The Problem

Mathematics has always been taught to Year 1 engineering students in the Department of Engineering at the University of Liverpool by lecturers from the Department of Mathematics. The Department of Engineering currently supports four accredited Engineering degree programme groupings: Aerospace Engineering, Integrated Engineering, Materials Engineering and Mechanical Engineering. Numbers have always fluctuated, but until recently there has been roughly the same number of students studying Mechanical Engineering as taking all the other three programmes in total. For at least the past 10 years, all Mechanical Engineering students took a very traditional rigorous Year 1 mathematical module, which assumed a good A-level Maths grounding (grade C or above was assumed). Aerospace Engineering, Integrated Engineering and Materials Engineering students all took a different Maths module. Students were therefore divided for their Maths teaching in Year 1 by degree programme.

In recent years, Maths entry qualifications for these four groups of programmes has been spread quite evenly between Maths A-level grades A-D and Foundation Year/other qualifications (including overseas). However, whereas many Aerospace Engineers had good Maths entry qualifications, a significant minority of students were entering with Maths qualifications towards the lower end. There was anecdotal evidence, supported by Maths diagnostic testing at entry (introduced for the 2001/2 session), that these students were not comfortable with basic techniques of algebraic manipulation etc. The Year 1

Mathematics module delivered to Aerospace, Integrated and Materials Engineers had initially adopted the same rigorous approach as the one delivered to Mechanical Engineers, but it was having to continuously adapt to include more remedial aspects of Maths topics in order to give the weaker students any chance of success. In essence, this meant more teaching of basic mathematical techniques, including algebraic manipulation and the application of mathematical formulae, and less rigour in terms of understanding the underlying mathematical processes (which was identified as important for Engineering students later in their courses). While this approach was successful in terms of helping the weaker students, some of the better qualified students were increasing becoming bored as they were not being stretched or stimulated, and were potentially being disadvantaged.

For the start of the 2002/3 session the whole approach to teaching Maths to Year 1 students in the Department of Engineering underwent a major review, both in terms of content and delivery. The only resource constraint was that two Mathematics teaching staff remain available for the teaching of the Year 1 cohort of typically 120-160 Engineering students in total. This review also coincided with the Department adopting a ~95% common Year 1 structure for all their BEng and MEng programmes.

The Solution

There were three main approaches, discussed in detail by Engineering programme directors and Maths teaching staff, in terms of how to better organise the teaching of Year 1 Maths:

1. Retain two Maths modules and split the students into two groups based on degree programme (as previously).

Main advantage: the Maths content and engineering applications used in teaching the Maths could be tailored for the specific engineering discipline, although with the introduction of a common Year 1 structure this was not felt to be very important.

Main disadvantage: it would retain the very wide spread of Maths ability within both groups.

2. Retain two Maths modules, both covering the same Maths topics, and split the students into two groups based on Maths ability (including their prior Maths qualification).

Main advantage: it would allow better students to be stretched (reducing the likelihood of them getting bored) and permit remedial teaching to the other group as necessary.

Main disadvantage: a process of dividing the class into the two groups would need to be agreed with staff and students, which optimises the learning process for each group, without allowing any suggestion that one group is taking an “easier” or a “harder” module.

3. Teach all students in a single large group, but run parallel remedial support sessions as necessary.

Main advantage: Uniformity of teaching style, content and assessment.

Main disadvantage: the Maths teaching staff did not think it would be possible to provide suitable content, delivery and assessment for the very wide spread of Maths ability in the group. Maths staff also felt that students who require optional remedial support are often the ones that do not take advantage of it. Remedial support can also be provided equally well within the other approaches.

After much discussion, approach 2 was agreed i.e. Year 1 students were “streamed” into two different groups, with both groups taught the same topics: Vector algebra, Differential Calculus, Functions of two variables and partial derivatives, Complex numbers, Integration and Differential Equations (Note: matrices taught in separate module). The division into groups was on the following basis:

- All students with Maths A-level grades A-C (about 70%) take a “standard” Year 1 Maths module. This uses what could be called a “rigorous” approach to teaching, including coverage of the underlying mathematical methodologies (and no access to formulae sheets for assessments).
- All remaining students (Maths A-level grade D, non-A-level qualification, ex-Foundation Year, and overseas students) initially assigned to a second Maths module. Primarily students are taught to use maths formulae to solve problems (with a formulae sheet provided for use in all lectures, class-tests, homework and examinations). While both modules utilise the same number of lecture hours, a weekly tutorial session is made compulsory for all students on this module.

Student performance in their start-of-year Maths diagnostic test, their first class-test around week 5, and (where applicable) their Foundation Year Maths module marks were all used to permit a small number of students to be moved “up” to the “more rigorous” Maths group in the first few weeks. Thereafter no movement between groups is permitted.

The most controversial aspect of the arrangements was assessment. Because the approach to teaching was so different, it was finally agreed that the two modules must have DIFFERENT assessments (i.e. different types of questions in their class-tests and exam papers) – although the re-sit exam paper each year will be common for both streams, including the provision of a formulae sheet. It was also agreed that, in order to overcome any perception by students that they may be

disadvantaged by taking a “harder” module, the teaching staff will co-ordinate their assessment processes to ensure that students taking the “rigorous” maths module do not fail the module if they would have passed the techniques-based maths module taken by students with weaker Maths qualifications. It was also made very clear to students that although both modules provide an adequate solid training in the essential Mathematical techniques that will be required of Engineering students in their second year, the “rigorous” maths module was more appropriate for Engineering studies if it was felt that they could cope with the rigour.

The Barriers

There were a lot of entrenched attitudes amongst teaching staff on all sides, ranging from extreme views that absolutely no compromise should be made to students with weaker maths backgrounds, through to serious concerns that with there being two differently assessed modules, no student should feel they are disadvantaged.

The Enablers

It was made very clear to students that although both modules provide a solid training in the essential Mathematical techniques that will be required of Engineering students in their second year, the “rigorous” maths module was the preferred one for Engineering studies if students could cope with it.

Evidence of Success

As of now, we only have initial feedback from staff-student forums and tutors on student reactions to this teaching approach, and these have been universally positive. As the main assessment and formal student feedback is only obtained at the end of the year, in the short term attendance at lectures and performance in class-tests will be used as a guide. From our viewpoint, we would like to know whether the new approach provides students with a more positive attitude and increased confidence towards the use of Maths in their engineering modules. This is difficult to assess!

How Can Other Academics Reproduce This?

Discussions have already been initiated to ascertain whether we may be able to widen the dual approach to Year 1 Maths teaching to include other engineering degree programmes which have a similar wide spread in Year 1 Maths ability, but insufficient student numbers to justify the allocation of more than one Maths lecturer.

A willingness of staff from both Maths and Engineering to devote a considerable amount of time (and make considerable compromise) was required in order to come up with a mutually agreeable outcome.

Quality Assurance

In situations where University policy requires that Maths is taught to engineering students by staff from a Maths department, it is important that procedures exist which encourage regular discussion between Maths and Engineering staff. This was not always the case in the past.

We now have a single identifiable member of staff in the Department of Maths with responsibility for Maths teaching to our Department and he attends Engineering staff-student meetings and programme review meetings.