Case study: Overcoming the maths problem

This case study describes a first year engineering mathematics module which is provided to large classes of around 230 students. The teaching methodology has been developed carefully to contribute to an enhanced learning experience. Student feedback indicates that clear presentation of material, good examples and provision of tutorial solutions on the intranet are significant factors. Students appreciate mid-term class tests, understanding that they promote a more structured approach to learning. Exam performance gives further evidence of effective teaching - over the seven years in which the course has existed the mean pass rate is 88% while the mean exam average mark is 65%.

1. Background

This case study describes a first year mathematics module provided for engineering undergraduates (aerospace, chemical, civil and mechanical – typical class size is 230) which has been in existence for seven years. A large majority of the Queen's University Belfast students enter university directly from school where they have achieved at least grade B in A-level mathematics. Typically the class has also included a small group of students with much lower qualifications in mathematics who have been admitted to their degree course having undertaken a preliminary course intended to improve their mathematical knowledge. For example, in 2007/08 about 48% of the class possessed A-level maths grade A, 25% had A-level maths grade B while about 10% did not have an A-level maths qualification (or equivalent). Students in this latter group would probably have GCSE maths with grades ranging from A* to C.

Students' mathematical difficulties are a well-documented national issue and the teaching methodology of this module has been developed carefully with that in mind. The objectives for the course were to:

- ensure competence in many basic mathematical techniques (e.g. applying methods for solving differential equations, matrix multiplication, calculating vector products)
- demonstrate application to engineering situations
- increase students' confidence in their mathematical ability.

2. Methodology

Teaching takes place over 12 weeks with two lectures and one tutorial/exercise class per week. Students attend lectures as a single large group but are divided into smaller groups (of 30–40) for exercise classes. The various aspects of the teaching methodology are outlined below, including comments from students (in italics):

- Much effort has been made to present the material clearly and logically so that students are able to follow their notes after the lecture. Numbering sections in the lecture notes (e.g. 1.1, 1.2, 1.2.1 etc) emphasises the structure and separates different topics. Numerous worked examples are included to help reinforce the material being taught and allow demonstration of potential pitfalls in the solutions. Typical engineering applications are incorporated to illustrate the usefulness of mathematics to engineers. Summary sheets containing key results are provided at the conclusion of major topics to help students extract the main points.

- When asked to indicate the most satisfactory aspects of the module, students most frequently refer to lecture notes and clarity of lectures:
  - *"Well structured notes. Very good for going back and revising."*
  - *"Notes and examples were very clear and well organised and easy to understand."*
  - *"Use of a lot of examples in lectures makes it easier to understand what is being taught."*

- *"The clarity of the lectures and the handy summary sheets. Building confidence in maths."*
- *"Because of the layout my understanding of maths has greatly improved."*
- *"Content clear, relevant, applicable to reality."*
- *"Clear targets and excellent notes."*

- Active learning and student participation during lectures are encouraged by the lecturer asking questions. Asking students to vote on various possible answers to a question promotes student participation without the pressure of speaking in front of the class.
  - *"Teaching style makes the topic very clear and easy to follow."*
  - *"Note taking helped focus throughout the class."*
  - *"Break during lecture helps concentration."*
  - *"Slightly informal so more enjoyable."*
  - *"Made learning interesting and being in class enjoyable."*
  - *"Used visual aids very well, made the course easily understandable."*

- PowerPoint is applied in lectures, for example, to develop a result term by term. Likewise, graphs can be constructed gradually and imaginatively. This helps retain students' interest while presentation is enhanced.

- In the more informal tutorials, students can obtain personal assistance with practice questions. Group working enables learning through another student's explanation or worked solution.
  - *"Plenty of opportunity to ask questions and resolve problems in the tutorials."*

- Class tests occur in weeks five and ten, each counting for 10% of the module mark. These encourage consistent working throughout the semester. Good performance in the tests increases students' confidence. Weak areas can be identified and targeted for extra revision before the final exam.
  - *"Class tests encourage learning as we go through the course rather than leaving it all to the final exam."*

- *Queen's Online* (intranet) is used extensively to provide detailed solutions to tutorial questions and links to web resources. Students have opportunity to check/work through tutorial solutions in their own time.
  - *"Good use of* Queen's Online *for tutorials and past papers."*

3. Issues

A major issue is the wide range within the class in terms of previous mathematical knowledge. Those with A-level Further Mathematics (around 7% of the total in 2007/08) tend to find the course material relatively straightforward and insufficiently challenging. While the tutorial questions include some more difficult problems in an attempt to maintain the interest of such people, the lectures are pitched towards the needs of the majority.

The class size introduced a barrier to quick feedback of class test marks. The format of the tests was recently changed – they now consist of multiple choice questions – to permit quicker marking and timely feedback. Subsequent exam performance suggested that this change did not have a negative impact on students' learning.

4. Benefits
Feedback from students suggests the following factors are particularly helpful with regard to their learning:

- clear lecture notes and explanations
- class tests
- intranet resources (solutions to tutorial questions and past exams).

5. Evidence of success
Student feedback, as presented above, has provided evidence of an enhanced learning experience. Exam performance has been very pleasing. Over the last seven years the exam average mark has ranged from 59.9–68.2% (mean 64.8%), while the pass rate has ranged from 82.7–93.8% (mean 88.4%). The external examiner has commented that the "average looks good, and there would appear to be relatively few failures, given the UK-wide picture of mathematics for engineers."

6. How can other academics reproduce this?
Other engineering mathematics lecturers could include class tests as part of the assessment, provide accessible tutorial solutions and summary sheets and introduce interactive elements to the lectures (e.g. voting). They should ensure that lecture notes are clearly and logically presented with appropriate headings and sub-headings and plenty of worked examples. This lecturer believes it is important to work through examples, writing the solution on the board/overhead projector with the students copying down the solution, rather than trying to explain a solution which has been provided on a handout to students.

7. Reflections
Student feedback indicates that an enthusiastic and personal approach, establishing a good rapport with students, is significant. This requires attending tutorial classes, talking to students, encouraging them, even trying to learn their names. This should mean students will find it easier to ask questions and attendance at classes should be greater. It is also interesting that students make a distinction between a lecturer and a teacher, with one student commenting that this approach was like having a *"teacher rather than just a lecturer."*

Background information

Discipline	*Engineering mathematics*
Participants	*230 students;1 lecturer; 1 postgraduate assistant per tutorial class*
Level	*First year undergraduate*
Pedagogical approach	*Demonstration of mathematical operations and methods, example-based learning, active learning*
Teaching methods	*22 x 1 hr lectures, 12 x 1 hr tutorials/exercise classes, group work during exercise classes, self study*
Materials required	*Self-prepared lecture notes, some notes/graphs on PowerPoint as appropriate, summary sheet and tutorial questions handouts, solutions to tutorial questions and past exams on intranet*
Assessment used	*2 x 50 minute class tests (multiple choice questions) each worth 10% of module mark* *1 x 2 hr exam worth 80% of module mark*
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Publication date:	*March 2009*