Curriculum Design

A look at issues confronting teaching and learning in engineering

Dr. Colin Turner

15th March 2006

Outline

1. Introduction
2. Constraints
3. Strategies
   - Module Design
   - Programme Design
   - Institutional strategies
4. Conclusions

Introduction

Why Me?

Introduction

The Retention and Progression Issue

Engineering has particularly acute issues in retention and progression. This is highly apparent in modules that delivery a strong flavour of content that the student regards as “alien” to their course.

The Mathematics Issue

These issues also appear when teaching mathematics to students for whom it is not their principal subject, for example, to

1. Scientists (Physicists, Chemists);
2. Engineers (both “Hard” and “Soft”);
3. Social Scientists.

Constraints

The Stigma of Mathematics

Mathematics holds an especially reviled place in the heart of many. They may have been taught in ways that make little or no sense to them, and the particularly cumulative nature of the subject means that they quickly become disillusioned.
They then come to fear and avoid the subject.

Therefore...

Frequently the students who need the most help are precisely those who will not ask for it.
Just as in trauma triage, we may have to look for the “quiet” as those most as risk.

Constraints

The changing secondary level syllabi

Over the last decade or more there has been a remarkable change in both the content of the GCSE and 'A' Level mathematics programmes, and their assessment. Despite this, participation in 'A' level subjects such as mathematics and physics has dropped considerably.

Therefore...

- We cannot afford to ask for these "hard" disciplines in recruitment (generally) any more.
- The students who have 'A' level are weaker than before, and the GCSE in mathematics is now valueless (IMNSHO).

Constraints

Widening Participation

We now have much higher (40%) participation than ever before, and in some cases we may still be attempting to deal with students as we did when we had 10% participation.

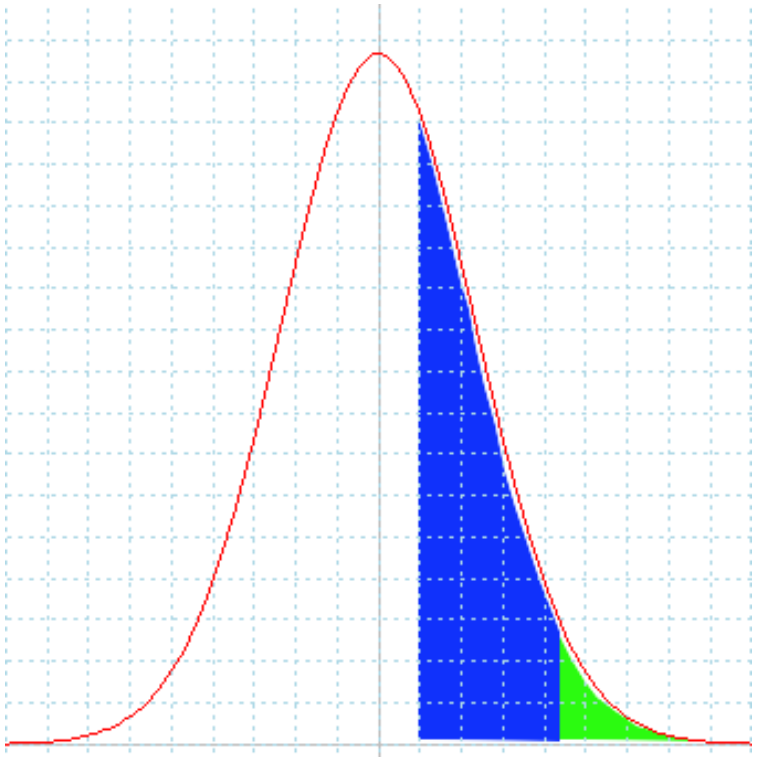
Therefore...

- We should consider ways of stratifying or streaming these students to enable them all to succeed individually to the greatest extent possible.

Constraints

Widening Participation

Consider the green in the figure to represent what was 10% participation, and the blue as the extra 30%. Picking whatever statistic you like on the x axis, can we really treat these as a homegeneous whole? If we do, this is a problem for all students.



Constraints

Changing Lifestyle

Students now spend considerably more time (and money) on their lifestyle in one way or another. This has also led to an increase in part time work.

Therefore...

- Students are often not aware of the need of work outside of the class;
- Students often do not attend even scheduled class time.

Strategies

This multi-factorial problem requires multiple strategies to be applied at the module level, programme level and even at the institutional level.
Let us first consider module design, and look at

1. module content;
2. content delivery;
3. assessment.

Strategies
Module Content

When considering the content of the module, it is vital to consider many issues including the following

1. variety of entry qualifications or previous modules;
2. syllabus of previous level;
3. requirements of other modules in the programme;
4. ethos of the programme;
5. learning outcomes;
6. literature base for the topic.

However, the most vital thing to consider, is the real baseline condition of the students, because much of the information above may be misleading in this regard.

Strategies
Module Content - Assessing the baseline

How can we assess the baseline condition accurately?

- Don't trust the syllabus of the preceding level;
- Don't assume that students will answer questions such as "Have you done this?" honestly.
- diagnostic tests may be useful, but may also cause problems of their own.

There seems to be little way to avoid the obvious conclusion that we must actually talk to the students, individually, or in small groups for many students.

Strategies
Module Content

Now we have to base our content around the real starting position of our students, aiming to meet the requirements of the next level.
The next major potential pitfall is trying to deliver too much.

Questions

- Is it better to teach 10 topics and have the students learn 3, or to teach 8 and have them learn 6?
- Are you teaching a topic that will have to be taught again, in its entirety at the next level?

Strategies
Content Delivery

Content delivery is at least as important as the content obviously.
There are many means of content delivery. In recent times some methods, such as exposition on a blackboard in a formal lecture have been much criticised.
Conversely, lab based study has become very popular, especially where work is structured to allow students to learn for themselves.
This may or may not be true, but resourcing issues also impact highly on these decisions.

Strategies
Content Delivery - Lectures

Lectures may not be the ideal means of teaching, but they can still be highly effective particularly if a spirit of dialog can be built into them.
It may well be that many of the failings found in lectures are down to the passive way in which most students (and some staff!) approach them.
However, we must always keep in mind that it will be the weakest students who will be the most likely to remain silent when they have problems.

Strategies
Content Delivery - Lectures

This leads me to my opinion that blackboards are the best tool for teaching mathematics. Why?

- It generates activity - someone is doing something!
- It allows for greater interactivity - more intermediate steps can be added when the brows are furrowing, and it is easier to take a detour when required.
- It helps ensure the pace is appropriate.
- With multiple boards it is much easier to lay out a large portion of a problem, allowing the context to be clear to the students.
- It allows students to pause and consider particular steps.
- The students think so too!

Strategies
Content Delivery - Tutorials

Most mathematicians agree that tutorials are a vital part of the learning process.
It is interesting to note that the correlation between tutorial participation and exam success is low. This is often a reflection that students with strong entry qualifications can often succeed well without them. For the weaker students they are invaluable, and we have to engage these (often shy) students with care; it is often the case that (paradoxically) they will stop attending when they feel they are getting lost.

Strategies
Content Delivery - Tutorials

Here are some thoughts on tutorials

- the tutorials must be small to be effective, at least for students meeting material at university for the first time;
- there should be a wide range of problems;
- the approach should be very non-confrontational;
- students should be encouraged not to be afraid to try problems they are unsure of.
- If possible the lecturer should attend some sessions, this can help underline his/her willingness to engage with individual students and to answer questions without humiliating the questioner. This improves interaction with the lecturer in “formal” lectures.

Strategies
Content Delivery - Lab classes

Lab classes can be a very helpful way of learning, like tutorials they focus on allowing students to discover things for themselves.
On the other hand, they are often very resource intensive.

Strategies
Examples

Now to look at some concrete examples of all of this. We have created three modules which can be used in various combinations

1. EEE001J1, level A.
2. EEE122J1, level 1.
3. EEE347J2, level 2.

Different programmes take different combinations of these modules in ways that help their particular issues.

Strategies
Examples - EEE001J1

EEE001J1

The key features for this module are

- attempting to address the shortfall in mathematical literacy;
- looking substantially at material which is GCSE (!) in nature, particularly looking at algebra, trigonometry, coordinate geometry;
- emphasis on small (one hour) lectures dealing with bite size theory;
- lab classes (two hours) based around excel to help lead students to their own discovery of the material;
- formal paper driven tutorials (two hours) to test the ability of students to use this knowledge away from the computers.

Strategies
Examples - EEE001J1

EEE001J1

The assessment for the module is by two open book class tests performed using Excel (but not a calculator).
I had initially included some marks for participation in tutorials and labs.
There is no formal examination.

Future improvements

I hope to make much of this material available in a more integrated web based manner (for those students who need this delivery).

`http://newton.engj.ulst.ac.uk/crt/teaching/EEE001/`

Strategies
Examples - EEE122J1

EEE122J1

The key features for this module are

- attempting to address the shortfall in mathematical literacy;
- covering substantial section from the 'A' level syllabus, particularly vectors, matrices, calculus.
- more lecture contact time (three hours), but with breaks and an emphasis on interactivity.
- formal paper driven tutorials (two hours) to let the students practice the theory.

Strategies
Examples - EEE122J1

EEE122J1

Assessment toughens up, two pieces of take away work initially (30% each), then a classtest (30%) and a little (10%) for tutorial participation.
A formal exam paper is also tabled. There is strong correlation between classtest and examination performance.

Future improvements

I want to distinguish material given in the tutorials more for different groups (for example, by programme).

`http://newton.engj.ulst.ac.uk/crt/teaching/EEE122/`

Strategies
Examples - EEE347J2

EEE347J2

The key features for this module are

- dealing with more substantive mathematics;
- covering material above the 'A' level syllabus, particularly Laplace Transforms, Fourier theory, Linear Algebra etc.
- more lecture time (four hours);
- full class tutorials (two hours).
- (In fact the lectures and tutorials are held in a combination of two hours of lecture time to one hour tutorial time, and this is sometimes mixed up).

Strategies
Examples - EEE347J2

EEE347J2

The assessment is four large pieces of take away coursework with a mixture of simple and sophisticated coursework requiring substantial extension of techniques offered in class. Here, learning is much more by assessment than at the other levels and much deeper.
A formal exam paper is also tabled.

Future improvements

Improvements required for “internal” notes.

`http://newton.engj.ulst.ac.uk/crt/teaching/EEE347/`

Strategies

We can address some of the constraints at the programme level too. Clearly all the design of the above modules occurred with the full involvement of all course committees to ensure that all needs were met.
First of all we can carefully consider the module diet for the student cohort.

Strategies

Some examples...

AB Engineering

- Study EEE001J1 initially (year 1);
- Study EEE122J1 subsequently (year 2);
- Some, planning promotion, study EEE347J2 (year 2);

Some ordinary degrees mirror this pattern, (e.g. BEng Electronics, Communications and Software)

Electronics, Communications and Software (Honours)

- Study EEE122J1 initially (year 1);
- Study EEE347J2 subsequently (year 2);

Strategies

However, module material is not enough, it is useful to spend time systemically dealing with the identity and other issues of the cohort.

- a coherent overview of the course will show if this is looked at across several modules;
- other initiatives can help, for example, studies advice (`http://newton.engj.ulst.ac.uk/crt/teaching/sag/`);
- or our school competition (`http://newton.engj.ulst.ac.uk/challenge/`).

Strategies

Some issues are best dealt with at the institutional level, or perhaps above!
However, there is also the possibility to use institutional and national strategies to help us. For example PDP[1] is a national strategy that we might regard ourselves as stuck with. On the other hand we can use the momentum behind these issues and built them into our own initiatives (for example, this is very cognate with studies advice).

[1] Interest declared: I am the university's undergraduate PDP coordinator

Strategies

We face many other challenges above the programme remit:
For instance, strategies to deal with the greater participation at university level should probably go hand in hand with an examination of “streams” of provision.
Right now the future of intermediate programmes, the ordinary degrees and the AB degrees for example, is uncertain in the University of Ulster and beyond.
However, a belief that “one size fits all” honours degree programmes can be made to suit all these students without damaging opportunity for any of them seems misguided.

Conclusions

- We are faced with many unpalatable constraints we can do nothing about.
- We therefore must work within them.
- Particularly we must design our programmes and modules for the real students we have.
- We have to address many of the other issues across many modules, and possibly also outside them all.
- We have to examine innovative ways of dealing with the broad range of students who are now participating and will be participating in the future.