Guide

Engineering Subject Centre Guide:
Guide to Lecturing

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The Higher Education Academy Engineering Subject Centre

Authorship

This guide is based on the chapter on lectures from *The Handbook for Economics Lecturers,* published in September 2002 by Economics LTSN.

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1 Introduction

"Some people talk in their sleep. Lecturers talk while other people sleep" – Albert Camus
"When I give a lecture, I accept that people look at their watches, but what I do not tolerate is when they look at it and raise it to their ear to find out if it stopped." – Marcel Archard
"My lecture was a complete success, but the audience was a failure" – Anon

Lectures have been employed for hundreds of years as a platform for disseminating ideas and knowledge and for guiding and motivating students, and they continue to be a cornerstone of higher education practices today. Lectures can be defined as the delivery of a course through a series of presentations by academic staff members to a group of students, usually with visual prompts and aids. The term 'lecture' can encompass a range of styles, approaches and formats that will be investigated throughout this Practice Guide. Some of these involve considerable student participation. Traditionally, however, lectures have involved the one-way transmission of course content from academics to students.

But lectures have more than a mere dissemination role. If their intention were merely to provide the students with basic information on the course then there would be good reason to simply abandon them and provide a competent set of notes in their place. Lectures should also motivate and challenge students and give them insights.

Of course, not everyone is capable of holding an audience spellbound throughout a lecture, especially when it is part of the routine of learning. Nonetheless, the lecture's longevity is clearly more than a quirk of academic tradition. The theories and ideas that are now discussed in lecture theatres across the UK may have progressed, but the lecture format itself has proved remarkably resistant to change. This Practice Guide will investigate the costs and benefits of different types of lecture, and will suggest ways in which the traditional lecture can be improved. Although the focus of this Practice Guide is on lecturing, it is not considered in isolation from the other teaching and learning formats that are likely to accompany and complement it.

1.1 Opportunities provided by lectures

Lectures provide key opportunities for students to learn about the subject they have chosen to study in an efficient way. The lecture will typically convey and prioritise information about the subject in a relatively condensed format. It can also enthuse students and provide a suitable framework for further study. Students are exposed, most likely for the first time, to a professional scholar who may be a researcher at the forefront of that aspect of the discipline. Lectures provide a traditional link between research and teaching. They help to preserve a culture of learning in higher education in which undergraduate study is viewed as an induction into an academic discipline, a way of viewing the world.

There are also clear benefits to the lecturer. Assuming that an academic is lecturing on a similar topic each year, the up-front costs of preparing a set of lectures are offset by their re-usability. Also, the traditional lecture, being teacher-centred, can minimise the stress for those academics that are hesitant to relinquish control of the learning process to students.

Lectures have additional benefits for the institution. It is seen as making an efficient use of the lecturer's time, since it allows teaching to take place in classes with a very high student/staff ratio. This is likely to become an increasingly compelling incentive in an era of declining resources. The Government's stated objective of increasing participation towards 50% of those aged 18 to 30 by 2010 while maintaining standards could, according to the Association of University Teachers, mean that higher education institutions would need to find places for up to 670,000 more students in this time.

1.2 Inherent problems with the traditional lecture

Notwithstanding the apparent benefits detailed above, newer approaches to learning and teaching, such as problem-based learning, are increasingly being introduced on the grounds that, even for an equivalent investment of staff time, the learning outcomes of students are far improved. The use of techniques that aim to involve a greater amount of student involvement is, of course, nothing new. Tutorials, seminars and other variations on student-centred learning have long been used to complement lectures. However, the justification for abandoning or reducing the number of lectures on a course typically focuses on the criticism that lectures are a poor medium, first for conveying information and second for developing student understanding.

Conveying information to students

Are lectures an efficient means of conveying information to students? According to Miller (1956), the average number of items that can be held in short-term memory is 7 (±2). Therefore, if students do not have significant time to process new information one of two things happens, either previous information is displaced or the new information is lost. Lectures which proceed quickly simply do not give students sufficient time to process information. Similarly, the ability to concentrate for an hour or so while taking adequate notes is not something that can be taken for granted. Indeed, listening and note taking can be mutually exclusive activities, especially for more inexperienced students. It cannot be assumed that an hour-long lecture will result in an equivalent sum of learning taking place within a student's head.

This problem can be compounded by the problems of a crowded curriculum. As new theories, research findings and policy initiatives emerge, space has to be found within the syllabus to accommodate them, and not always at the expense of existing content. If more and more content is crammed into a series of lectures it may encourage the lecturer to do little else but talk from the front from start to finish. The logical consequence of such practice is that the pace of lectures is forever quickening to ensure that the expanding syllabus is

covered. A lecture could hardly be considered successful if it 'covered' the appropriate part of the syllabus and yet students retained little of what was said or were not guided in their private study.

Students are also more likely to remember information when it is structured in a logical fashion and if it is demonstrably meaningful to them. This again highlights the importance of context to learning. Students need to comprehend why they are being taught what they are and how they will subsequently be assessed on it.

Developing student understanding

To judge the 'success' of a lecture, it is important to identify its intended learning outcomes. Again, it could hardly be considered successful if it 'covered' the appropriate part of the syllabus and yet students retained little of what was said or were not guided in their private study. Learning outcomes are often specified in module or course descriptors or handbooks. However, caution should be exercised in judging the success of a lecture against them, since these parts of the documents have often been prepared to meet university or QAA requirements, and compliance in this process by lecturing staff does not necessarily mean that the specified learning outcomes are the most appropriate or are even the ones that the lecturer would choose to identify.

In addition, whilst a lecture's success should be judged in terms of what students gain from it, it does not follow that lectures which students consider successful are necessarily good lectures. Students may prefer lectures that allow them to take notes which can be used directly in preparing for examinations or other forms of assessment. If their objective is to maximise marks subject to a time constraint, or to minimise time commitment subject to achieving a target mark, then this will almost certainly be the case. Similarly, a lecture might be very entertaining, and for that reason popular with students, and yet be a poor learning medium. Students are also likely to show a preference for the teaching format they are familiar with, as is equally the case with lecturers.

Assessment is clearly an indicator of student learning and hence of the success of lectures. But even if it were possible to separate the contribution of lectures from other learning media to assessment performance, the assessment itself may not capture the extent to which students have acquired and developed an understanding of the subject matter. To gauge this it is necessary to consider a theory of learning first developed by Marton and Säljö (1976a, 1976b) and since elaborated by Ramsden (1992), Biggs (1987, 1993) and Entwistle (1981). In these studies an important distinction is made between surface, strategic and deep learners. Surface learners are characterised as focusing on memorising words, formulae and theories rather than building relationships and connections. Surface learning is encouraged by:

- a heavy workload;
- an excessive amount of course material;
- a lack of independence;
- assessment methods that emphasise recall and create anxiety;
- poor or little feedback on progress;
- a lack of interest in the subject.

Deep learners seek to relate theory to practice in a range of different contexts. They are able to organise their impressions into a coherent whole rather a set of disassociated facts. Deep learning is encouraged by:

- a choice over content and study methods;
- teaching methods that build on existing knowledge and experience;
- active involvement in learning;
- long-term engagement with the subject.

Strategic learners will adopt whichever approach they believe will maximise their grades. If they believe, rightly or wrongly, that the form of the examination rewards memorisation of disparate facts, they will adopt a surface approach. If they believe that the examination will reward a holistic understanding of key ideas or concepts and how these apply in different circumstances they are more likely to adopt a deep approach.

Most students cannot be so readily pigeon-holed, displaying characteristics from two or more categories at any one point and may change their preferences over time. Nonetheless this theory exemplifies the potential shortcomings of a wholly didactic model where it is assumed that what is not said is not learnt. The purpose of this Practice Guide is not to debate at length the merit of these models (further reading references are provided at the end), but to establish that the intention of any engineering course should be more than simply to allow students to adopt surface-learning strategies that promote the accumulation of transient non-contextualised knowledge.

Finally there is the issue of the diversity of ability and prior experience of students. This is especially a problem in the first year, where lecture groups tend to be larger, where some students can have a diversity of subject backgrounds and where exit routes can vary from BSc to BEng to MEng qualifications. How can a traditional lecture cope with diversity? At which students should the lecture be pitched? What back-up support will be necessary for the weaker students and what additional learning activities will stretch the stronger students?

2 Good lecture practice

2.1 Student preparation for the lecture

In some cases, it may be appropriate for students to come to a lecture 'cold', especially if it is an initial scene-setting lecture. Generally, however, students will gain more from a lecture if they have done some preparatory work. You could assign them reading or specific tasks. If so, you would probably have to address the question of incentives for students to do this work. This could amount to simple encouragement in previous lectures or in handbooks or online information where the importance of the preparatory work was stressed. Alternatively, it could be built into a more formal process of study, leading to some specific individual or group work by students.

Top Tip 1: Giving preparatory work for the lecture helps students to see the relevance of the lecture and they will probably learn more.

Prior work could include:

- using the Web to provide background information;
- revisiting relevant theory covered earlier. The lecture could start with a quick 'quiz' using multiple-choice questions (see below on the technology for quizzes and tests in lectures);
- asking students to identify a set number of issues to do with the topic. This will help them to contextualise the material and see its relevance. These issues could be posted to a discussion board, so that other students could read them;
- assigning reading to be completed before the lecture. This could be an introduction to theory or relevant evidence, perhaps from a textbook or an article. A brief quiz on this could be given at the beginning of the lecture, so as to provide an incentive for the students to do the work.

In all the above cases, clear guidance will need to be given to students about what is required of them. This could be given in student handbooks, but should probably be reinforced by having a discussion early on in the course about the role of lectures and how students can maximise the learning benefits from them.

2.2 Effective presentation

Students are likely to learn more if a lecture is well structured and well presented. Not every lecturer has a charismatic personality, but students can still be engaged and find the lecture an effective learning experience if thought is given to the structure and method of presentation. This section reviews four issues in planning the structure of a lecture: aims and learning objectives; overview and clarity of structure; use of examples and pace. The

second half of the section examines three aspects of method of presentation: presenting graphs and equations; using boards, OHTs and PowerPoint; and using videos. The section concludes with some observations on dealing with disruption.

Aims and learning objectives

It has become commonplace for lecturers to give the aims and learning objectives at the beginning of a lecture, usually in the form of an overhead transparency (OHT) or a PowerPoint slide. One of the main drivers for this has been Subject Review and the stress placed on making intended learning outcomes transparent. Whilst it is good practice for students to see the purpose of what is to come in the lecture and what they are supposed to learn, beginning the lecture with a bullet list of aims and learning objectives in educational jargon can be a 'turn-off' for students. It is important to communicate in 'student-friendly' language. For example, if the learning objectives of a lecture include an understanding of a particular theory – its properties, its assumptions, how it can be applied and what its limitations are – then state this as such, rather than in terms of, say, the development of cognitive or analytical skills.

The format of lecture objectives also gives students an indication of the approach to learning that is expected of them. For example, an objective in the form ‘Movements along and shifts in the demand curve’ implies that students are required to memorise a list of causes and how to depict these on a simple diagram. An objective ‘Analyse changes in the demand for consumer products using a market demand curve’ implies that the focus of assessment will be on understanding examples of economic behaviour in practice. The signals communicated by these objectives may indicate to students whether surface or deep learning is expected.

Top Tip 2: Students need to comprehend why they are being taught what they are and how they will subsequently be assessed on it.

Overview, contextualising and clarity of structure

At the start of a lecture it is even more important to give students a sense of how the lecture fits into the syllabus and how it follows on from the previous lecture. A ‘lecture map’ on an OHT or PowerPoint side can be used to outline the structure of the lecture in terms of main topics, issues and theory. This summary can be referred to as the lecture progresses, helping to retain and reinforce the students' grasp of the lecture's structure. This can also be referred to at the end as part of a brief summary of what has been covered.

Top Tip 3: If you give the students a 'lecture map' on an OHT or PowerPoint slide this can be referred to as the lecture progresses, thereby helping to retain and reinforce the students' grasp of the lecture's structure. This can also be referred to at the end as part of a brief summary of what has been covered.

Use of examples

Brief up-to-date examples, or appropriate historical examples, can make the lecture much more interesting for students and help them to see the relevance of theory (see Case Study 1). Careful thought should be given to the number and nature of examples. Too many examples and the students might not be able to 'see the wood for the trees'; too few examples and the material could appear dry and disconnected from reality.

Examples could be very short: for example, reference to some current news item or to some real examples of something (e.g. photographs and images). Students' understanding of engineering concepts is likely to be much better if they can relate them immediately to the context. There is a potential cost of using examples in terms of time not spent covering additional material, but again, if the success of a lecture is to be judged in terms of learning outcomes, this may be a cost worth incurring.

Pace

Pace is crucial to the success of any lecture. It is very easy for lecturers to imagine that if something has been said, then it has been understood and absorbed by students. Part of this mindset is the perception of students as receptacles: ‘At the beginning of the lecture, you lift the lid on students' heads, pour in an hour's worth of knowledge, close the lids and the students walk out wiser than when they arrived’. Although we all know that this not how students learn, we are frequently faced with the dilemma of how to ‘cover all the material’ in the lecture.

The problem stems from two main sources. The first is that courses that have become tightly structured to meet the requirements of auditing and quality assurance. This can remove the flexibility of being able to vary the pace and content in response to student feedback or current events. The second is an increasingly crowded curriculum. Whilst we strive to keep courses up-to-date and include new theoretical developments, legislations and applications we are reluctant to delete an equivalent amount of old material. So should we keep adding new developments to the existing course? Our module specifications say that in lecture *x* we will cover topic *y*, and yet in topic *y* we want to include more and more each year. What is the solution?

The solution is not to speak faster and faster! Students would almost certainly end up learning less, not more. Either you have to reduce the syllabus content so that it can be covered in sufficient depth and at an appropriate pace within the lecture time, or you have to abandon the notion that the lecture should be used to 'cover' all the material. If this latter is to be the solution, then you have to plan carefully how the lecture fits in with the remaining parts of the students' learning. Is it to be used to introduce topics, to go through the core theory or to give pointers or examples not available elsewhere?

Pacing is not just about covering an appropriate amount of material. You will have to decide exactly what you want students to *do* in lectures. If you merely want students to copy down notes, it would probably be more efficient to give them the notes as a handout or post them on your intranet. Presumably, you will want students to understand what you are covering, to see its relevance and to be motivated to learn more. In that case, the pacing must take account of this. The planning and delivery of the lecture will need to balance demands on students' writing, listening, watching and understanding. It is too easy to put up an OHT or a complete PowerPoint slide and then start talking about it straight away. What are the students to do? Are they to copy it down or concentrate on what you are saying? If you want them to take something down, it might be best to pause while they do so, especially if it is something they are unlikely to grasp immediately.

An important part of pacing is recognising the attention span of students. This tends to drop off quickly after 10 minutes, unless the students are particularly excited or fascinated by what you have to say (see Bligh, 1998). Part of the solution lies in varying the pace through examples or anecdotes when attention is likely to flag. You could vary the use of visual materials, so that sometimes the students would be concentrating on them and at other times on you; sometimes copying things down and at other times just listening or composing their own notes. The key is to inject light and shade: to vary the tempo, the nature of the material and what is required of students. Alternatively you could move away from the lecture being solely a talk and engage the students in various activities. Some suggestions are given in section 2.3.

Using boards, OHTs and PowerPoint

Whether using the whiteboard/blackboard, OHTs or PowerPoint slides, it is important to give careful thought to what you want the students to do. In lieu of any other guidance, students will assume that you intend the displayed material to be copied down. If used well, visual materials can considerably improve learning by providing a clear structure for the lecture. If the structure remains on the screen, or is referred back to at the start of each new section, students will find it easier to see how the various parts of the lecture are related, even if their attention wanders for a period of time. Similarly, if students lose the thread of an argument, they will be able to pick up the thread from a ‘lecture map’ presented on a slide or board.

But how much material should you display? If you display a lot, students will spend a relatively large proportion of the lecture simply copying things down. Is this an efficient use of their time? Would it be better to give them a handout or post the material on the Intranet? If you do want them to copy things down, then you must allow enough time for them to do so.

An advantage of using a board is that your writing speed imposes a natural brake on the rate at which students have to process new information. However, if you are talking while you are writing, students will have great difficulty in listening to what you say, copying what you write, and adding notes on what you are saying. Also, some students may find difficulty in reading your handwriting, or in hearing what you say if your back is turned while you are writing.

If you use OHTs or PowerPoint slides the problem of note taking can be worse as the slides are already complete. Too often, lecturers display a slide and then start talking about it straightaway. What is the student to do: copy the slide or take down your comments? For experienced lecturers, this may sound obvious, but it is easy for all of us to fall into the trap of expecting students at one and the same time to copy a slide *and* to listen to our commentary on it *and* annotate their copy accordingly.

One solution to the time constraint is to give students your lecture slides in advance, whether in hard copy, or as Word, PowerPoint or other file types. If the slides are merely headings, the students can then make their lecture notes under them.

If you are using PowerPoint, you can animate your slides so that bullets or paragraphs or stages in a mathematical demonstration appear one at a time. Similarly you can animate graphs by having lines appear one at a time. They can easily be made to shift in the required direction. A little playing around with the 'Slide show', 'Custom animation' feature can enable you to display diagrams in an interesting and effective way.

Top Tip 4: Whatever media you use, it is important not to display too much material and to give students time to take things down.

Using Skeletal Notes

Skeletal notes can be used during lectures to improve attention by the students and promote deeper learning (see Case Study 2). (They can also help prevent students missing lectures because they can download all the handouts from your website). Skeletal notes are a full set of the lecture notes, provided to the students, that have key pieces of information missing from them. These missing pieces of information could be the right hand side of an equation, an entire equation, a definition, etc. The missing pieces are then added by the students during the lecture. This means you can almost eliminate the “copy the slide or take down your comments” dilemma from the students, and help them to see the importance or relevance of the missing piece of information. This can also release a little time in lectures for some interaction, or even for the students to test out a theory through calculation – the

space for this could also be built into the handout. This approach has proved to be very popular with students at a number of institutions.

Presenting graphs and equations

If you are using OHTs or PowerPoint slides, an effective way of presenting graphical or mathematical material is to give the students a half-complete diagram or proof which is completed during the lecture. For example, if you were presenting a model which shows an initial equilibrium position and then the effects of a shift in one or more curves, you could give the students the initial position (with or without the equilibrium marked) and ask students to complete the diagram. This is particularly useful for complex diagrams. Not only does it save time by avoiding the need for students to copy down the initial part of the diagram, but it also ensures that students can focus on the key points you are making. It is also likely to mean that the finished diagram that the students are drawing is accurate.

This approach allows learning to be an active, yet efficient, experience. Learning is likely to be more active if you ask the students to complete the diagram or proof first and then you go through it. But even asking students to copy down the additional material is likely to make learning more active and effective than students rushing to copy a complete model. If they are copying the key parts (e.g. the effects of a shift in a curve), they have more time to reflect on what is happening in the model.

Resources provided in this way may cause problems in terms of cost and equal opportunities. Can your department afford to make copies free to students? If you make them available electronically, what will you do about students with no personal access to a PC or a printer? Is it acceptable to sell these materials to students? One solution adopted by several departments is to produce detailed course handbooks with lecture outlines. These outlines could contain the partially complete diagrams and proofs. The handbooks could be sold to the students at cost, with all students expected to purchase them. However, this practice incurs up-front cost in preparation time, and reduced scope to amend the teaching programme in response to student feedback.

Use of videos

Many lecture theatres are equipped with video players, to be used either through large televisions or through a data projector. Alternatively, many lecture theatres permit the playing of DVDs through a PC or laptop and data projector. Video streamed material can also be displayed through a data projector via a PC or laptop. The quality of video streaming, however, is considerably inferior to that of VHS and DVDs. Whichever projection method is used, video images can add substantially to the impact of a lecture.

Two important questions to consider in using videos are ‘what length of clip should I use?’ and ‘what are the best sources of video material?’ If the video is being used to illustrate a point it is best to keep the clip to no more than five minutes. This change of media and pace

can aid students' concentration and help them to see the relevance of points you are making. Even with a short video clip, the relevance of the clip may not be obvious to all students. You may well need to introduce the clip so as to prime students about what you want them to gain from it.

Top Tip 5: Video clips, if used carefully, can considerably enhance student learning by helping to contextualise material through the provision of examples. By providing interest and variety in a lecture, they can increase student motivation and interest.

Sometimes you may wish to show a longer extract. For example, you may wish to use the video as a case study. There is a potential problem here. With the exception of videos made for educational purposes, the pace and structure of the video may make it difficult for the student to make notes. If this is the case, you might find it useful to display some bullet points on an OHP while the video is playing. These could help to make the structure of the video more transparent.

One of the most effective uses of video is to give a topical illustration of a point or to set the scene with something in the news. Probably the best sources here are news magazine programmes, such as Newsnight on BBC2 and Channel 4 News. Other broadcast sources include Panorama and The Money Programme.

Most universities hold an ERA (Educational Recording Agency) Licence. This allows free use of TV material for educational purposes. The licence permits you or any other university employee to record programmes off the television at home or at the university, to make multiple copies (e.g. for depositing in the library) and to compile extracts. You can edit, but not adapt the recordings. You can show all or part of a programme, so long as it is for educational purposes. The video/DVD should be labelled, 'This recording is to be used only for educational purposes'. Open University recordings require a separate licence. There is no licensing scheme to cover cable or satellite broadcasts and you are free to copy and show these. It is advisable to check with your university the precise nature of what you can and cannot show.

Dealing with disruption

Hopefully, you will not experience this. If you do, you need first to be aware of why the disruption is occurring. It is likely to stem from lack of student involvement and boredom. While it would be nice to think that you are so charismatic that this could never occur, the solution lies not so much in how good a performer you are, but rather in what the students themselves are being required to do in the lecture.

If they are merely being required to listen for an hour, they are very likely to get bored unless you are a superb entertainer. To keep students engaged, try the following (several of which are examined in more detail below):

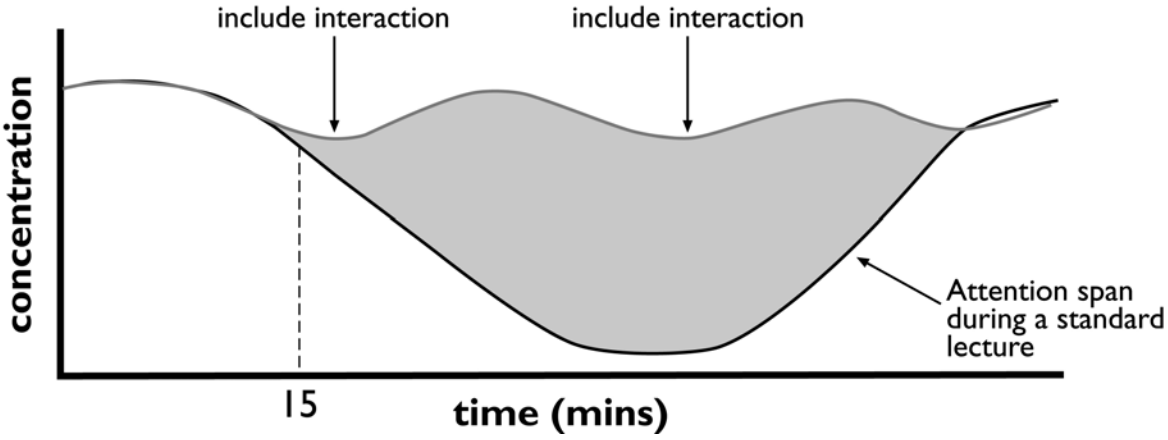
- ensuring that they have a clear understanding of the structure of the lecture and its relevance to the rest of the module;
- changing the pace;
- giving students different activities (such as short questions to test their understanding);
- making it possible for them to take notes by not going too fast;
- making careful use of visual aids;
- illustrating points with examples;
- giving them one or two short breaks.

Sometimes students studying engineering are doing so reluctantly, either because the subject has turned out to be different from what they had expected, or in some cases because they couldn't get onto their first choice course. The solution here is to ensure you contextualise the learning and focus on the relevance of the topic (and the module) to the subject as a whole. If, despite the above, students are disruptive (by talking, leaving the lecture, coming in late, etc.), then deal with it directly. If you ignore it, it will probably get worse. First, try talking to the whole lecture group about your expectations of them and why 'good behaviour' is vital. Then, on any subsequent occasion when disruption occurs, address the culprits directly and, if necessary, ask them to leave.

2.3 Activities in lectures

An hour (or even 50 minutes) is a long time to listen and concentrate. As we have seen, concentration and retention rapidly diminishes after 15 minutes. Not only should student learning be as active as possible, it should be efficient. Ideally, a student should be able to:

- identify main points;
- distinguish the important from the diversion;
- identify when the same point is being presented in different ways;
- perceive connections (e.g. between one theory or part of a theory and another);
- relate examples to concepts and theories;
- relate evidence to propositions.



These can all be aided by careful use of activities in lectures and this section examines different types of activity that could be used. The inclusion of activities comes at the expense of time the lecturer would otherwise spend in talking to the students. The case for using activities is that the breadth and depth of students' understanding is increased even though the sheer quantity of information communicated by the lecturer is reduced.

Top Tip 6: The more active the participation of students, the longer and better they will be able to concentrate.

Tests/quizzes

One of the most effective ways of making learning a more active process and helping students to check on their understanding and learn from their mistakes is to give them questions (see Case Study 3). The simplest forms include multiple-choice, true/false or listing. The questions can be displayed on an OHP or a PowerPoint slide although, as Case Study 4 illustrates, there are more sophisticated ways of doing this. Setting a question at the beginning of a topic allows students to grasp the theoretical points you are making, having first considered some examples and relating your arguments to them.

Alternatively, the questions could be given at the end of a section or after the delivery of an important concept. This could then test students' understanding. If you then asked for responses (e.g. 'hands up those who answered A'), this would give an indication of how well key points had been understood. You might also ask students to write down their answers and pass them to their neighbour to mark. When students see what their neighbour has written they can learn from each other as well as from the lecturer, especially if they are asked to spend a couple of minutes justifying their answer to their neighbour.

Top Tip 7: The use of multiple-choice or other simple response questions two or three times per lecture can help to provide a break in pace, an opportunity for reflection and reinforcement and a check on students' understanding.

Worksheet or material on OHP

An alternative to short questions is to give the students a problem or some data to consider. This could be on paper, with the students picking up a worksheet at the beginning of the lecture, or it could be displayed on the OHP. It is normally a good idea for students to attempt such questions in pairs as they can learn from each other. It also makes the exercise more fun. You can then go through the question from the front. You might also ask students to read a passage that you hand out and then to answer one or two questions on it. The passage could be from a newspaper, book, journal or magazine. It is probably best to make the questions relatively closed. For example, if the lecture focuses on health and safety you could give them a brief news article reporting on a engineering accident or disaster and then ask them to identify the possible causes of the situation. More open-ended questions are normally best considered in tutorials/seminars where students have the opportunity to discuss their answers with the group.

Completing diagrams or proofs

Copying down mathematical derivations or diagrams can be a fairly mindless exercise. Giving students a partially complete proof or diagram and then asking them to fill in the extra material can help (as argued above), since the student has time to reflect and to focus on the key points you are attempting to convey.

You can make this process more active by stopping part way through presenting a derivation and getting students to fill in the next step. They can do this individually or discuss it with their neighbour. Alternatively you can test their understanding at a particular point by asking them which way a particular curve shifts if you change a particular variable or getting them to repeat a particular mathematical step using different numbers.

Making lists

These can be useful for getting students to think expansively or to think about legislation or other implications. For example, you could ask them to identify a list of advantages and disadvantages of a particular design. They could do this individually or with their neighbour; or they could start by doing it individually and then compare their list with their neighbour's or get their neighbour to mark them against a list that you supply.

A lecture/workshop hybrid

You might restrict the formal lecture on a topic to 20 minutes and then set students some work to do, either through a worksheet or questions on an OHP. The questions could be in the form of calculations or data response, preferably of the closed variety. You could go through the questions at the end, or post the answers on your Intranet. Alternatively, you might give students a set of questions on a case study or an article. The formal lecture might be presented as a follow-up to the questions or it might be used to introduce the key ideas that will be investigated further through the questions. Either way, it is important for you to integrate the case study or article carefully with the lecture to ensure that students are getting the best from both parts.

2.4 Use of breaks in lectures

Given the decline in student attention after some 15 minutes, it makes sense to give students a break during the lecture. When the lecture resumes attention is likely to be restored to its original or near original level. This does require, however, that you avoid the temptation to fill the lecture time with you talking, under the mistaken belief that the more you succeed in saying, the more students will be receiving.

If you do opt to give students one or more short breaks, there are several things that you can ask students to do with this time. Some are related to the lecture; some are not.

Breaks related to the lecture

You can ask the students to use the break to reflect on what they have learned so far in the lecture. A good way of using this 'pause for reflection' is to get them to look through the notes they have taken and 'revise' what you have covered in the first part of the lecture. If this lecture follows on from a previous one, you could also ask them to check that their notes follow on from the previous lecture.

Top Tip 8: You could ask students to compare and discuss notes with their neighbour. Students will benefit from giving as well receiving feedback.

Breaks unrelated to the lecture

The simplest form of break is to give the students a few minutes just to stop and have a bit of quiet time or to chat to their neighbour. If the room lends itself, you could let them move around. Such breaks can get noisy and so it is important to set 'rules' that allow you to end the break quickly so that the lecture can resume. An alternative to the 'pure' break is to provide some form of entertainment. Many lecturers may feel uncomfortable about this, but it can prove very popular with students and the complete change can be very effective in helping to restore concentration. For example you might show an entertaining video clip or

read a diverting and interesting text. The video clip could be a cartoon or a comedy sketch, or anything that you feel the students might like (within reason). You could even serialise a programme. Alternatively you could show an engineering-related item from the week's news which, even if unrelated to the lecture, can reinforce the relevance of engineering to everyday life. You might choose some text from a news extract or even a poem. You could even arrange with a colleague to come into your lecture to read something (a 'favour' you could reciprocate). You could assign students in rota to bring something to read out – although you may have to vet their contribution in advance!

Top Tip 9: A short 'entertainment' break is likely to prove popular with students and thereby improve motivation. The break would improve concentration afterwards. If students end up learning more, it could be time well spent.

2.5 Overcoming barriers to more active learning in lectures

Section 2 has presented a number of alternatives to traditional practice in engineering lectures. Whilst these approaches are becoming increasingly common in practice, there are a number of barriers which restrict their adoption:

- preparation time: preparing materials (e.g. PowerPoint slides), rewriting lecture notes, etc.;
- other time costs: maintaining a Virtual Learning Environment, answering student questions in an online environment, the time taken to gain and evaluate student feedback;
- risks: students may react adversely to being challenged (at least initially); the new methods may not be successful in terms of learning outcomes as hoped; you may feel uncomfortable in a new lecturing environment;
- reactions of colleagues: if you take a 'radical' approach to lectures, and the students like it, there could be an adverse reaction from more conservative colleagues; there may be a departmental expectation of what a lecture should be and this may be a very traditional model of 'covering material';
- financial considerations: the use of technology (such as a personal response system or aspects of a Virtual Learning Environment) may require hardware, software and technical support, all of which may be blocked for financial reasons.

Given the above, it is often easier to introduce change iteratively. Try some small activity in a lecture that takes no more than a few minutes, or try introducing a break for a couple of minutes. See how successful it is. Try revisiting your learning objectives and asking whether the lecture really addresses them. Consider whether you are making the best use of the materials you make available to students. Do they contain too much or too little material? Should they be made available before or after the lecture? Revisit how the tutorials build on the lecture material. Consider how you present information on OHTs or PowerPoint slides.

Do you want students to copy them down? Why? Are you giving them long enough? What work do you expect your students to have done before the lecture? Should you assign specific preparatory activities?

This is not to say that you should not introduce radical change, but a progressive approach is probably safer, less costly and more practical. Try limiting changes initially to things that do not take up more time. Once you have learned how to manage the new processes efficiently they may save you time. For example students may use more forms of self-help and rely less on coming to see you, or you may be able to rely more on FAQs on a discussion board. This could then allow you to devote more time to other forms of student support or to developing materials.

3 Building on lectures and student support

What do you expect your students to do to build on the lecture? What support do you offer them and how can this be provided in a cost-effective way?

3.1 Work for tutorials and problem classes

Typically, lectures are directly related to tutorials or problem classes and it is worth stressing the importance of carefully integrating the two. You will need to address the following questions:

- How much time do you want students to spend on tackling tutorial questions and follow-up private study after the lecture before coming to the tutorial? This should be made clear to students so that they can maximise the benefits from the tutorial. It is unwise to assume that students will know what is expected of them.
- Do you want to refer back to material or activities in previous tutorials? If you do, this is likely to give students a greater understanding of how the course is structured.
- Do the tutorial questions directly relate to the material covered in the lecture? Here you will need to decide whether the lecture material needs reinforcing through tutorial questions or whether the tutorial could be used for follow-up work.
- Do you use some of the time in tutorials to allow students to ask about points they did not understand in the lectures? Do you actively encourage them to do this? If so, are there any other ways of achieving the same objectives that you might consider using, such as discussion boards to which you reply or student self-support groups (see section on VLEs)? These alternatives could release tutorial time for other activities and prevent them becoming, in part, a repeat of the lecture.

It is impossible to give answers to these questions that are appropriate to all circumstances. The most appropriate answer will depend on the nature of the learning objectives and the type of work students are expected to undertake outside of lectures and tutorials. However, it is important to stress the need to integrate the lectures and tutorials and to use each to complement the other.

3.2 Online materials

Posting materials, such as lecture notes and copies of PowerPoint slides, has become commonplace. These could be within a Virtual Learning Environment (VLE), such as Blackboard or WebCT, or on the course website, Intranet or shared drive. If learning in

lectures is to be an active experience for students, you will need to have a clear strategy for the use of these materials. If they are too detailed and follow the lecture very closely, they could be seen as a substitute for the lecture by the student. You may well want them to be so, thereby giving students greater flexibility in their modes of study. In this case, however, you will need to address the issue of students merely downloading the materials and not actually using them, but being lulled into a false sense of security that they can use them 'later'.

Online materials can support student learning more effectively if they are integrated with the tutorial programme and related to assessment. If your course is in a Virtual Learning Environment you can use its features to organise the materials within the scheduled programme and, if you choose, make them available for only a specific period of time. This can provide an incentive for students to access the materials shortly after the lecture.

More creative use of online materials as a follow-up to lectures would include interactive 'study guide' questions. For example, if you were covering a particular theory in the lecture, you could set a series of questions online for students to test, consolidate and deepen their understanding of the theory. These questions could be multiple choice, problems or manipulating graphs. You could choose whether to make the answers available online.

If you are using online study guides, you will need to decide what incentives there will be for students to use them. How closely will you link them to assessment? Will you encourage students to work in small groups and what are the incentive mechanisms for encouraging them to do so?

3.3 Use of interactive facilities in VLEs

This section provides a brief overview of possible links between lectures and a VLE.

Discussion boards

One useful mechanism for encouraging students to make full use of their learning in lectures is to set up a discussion board. This is easy to do in a VLE but even a conventional email list can serve the purpose. You can post questions on the lecture that follow on directly from its contents and students would be expected to respond. You can 'require' students to make a set minimum number of contributions. You can log their contributions and decide on an appropriate encouragement or 'penalty' for students who do not contribute.

If you do set up a discussion board, you will have to decide what students can expect of you. If you merely 'pump prime' it and then expect students to make all the contributions, it can be relatively undemanding in terms of your time. If used in this way, it can be a very useful mechanism for promoting a culture of mutual self-help.

Follow up questions by students

You could encourage students to contact you if they have queries about the lecture. If you do not want to answer the same question over and over again, then you could again use a discussion board with a 'frequently asked questions' (FAQ) section. Once you have answered a question once and posted the answer, then you will not answer it again. The students would be expected to consult the FAQ section to check that any question they ask you has not already been answered. This can save you a lot of time and is very useful for encouraging a culture of self-help in learning, rather than students simply expecting 'to be told'. An FAQ section could be substituted for half of your office hours and you could dedicate the released time to answering the online questions.

Top Tip 10: Encourage students to answer questions posed by other students after the lecture on a discussion board. You need only intervene if the students were not working their way to the 'right' answers. This is a mechanism for encouraging self-help.

3.4 Assigned work

Assigned work: private study

Rather than merely expecting students to follow-up the lecture by reading or working through questions, you could assign them work to do. If you are not assessing this assigned work, whether summatively or purely formatively, you will need to provide incentives to encourage students to complete it.

You could emphasise the intrinsic benefits of the work in helping them to improve their understanding and, thereby, their final grade. You might also emphasise the development of subject-specific and generic skills that will be of benefit to them later in their studies or in their career. The use of log books or personal development planning (PDP) would help to encourage this more holistic and reflective approach.

The assigned work could help students to prepare for the next lecture. For example, if in the next lecture you are going to develop a theory that you have introduced, you could set students a couple of case studies that put the theory into an applied context or set a couple of problems that require the students to use the theory. This type of work can help students to see how the lectures are linked. It is useful to pose one or two questions at the beginning of the next lecture to evaluate this work. These could be in the form of multiple-choice questions on an OHP. A show of hands would be a simple way of checking how well the students had answered them. A Personal Response System is a more sophisticated approach (see Case Study 1 below).

Assessed work: formative and summative

There are several ways in which lectures can be linked to assessment. First, students' understanding of the material may be tested directly. A tutorial shortly after the lecture could begin with an objective test, a problem, or a case study. Second, the lecture could be directly relevant to an examination or formally assessed assignment. Students are likely to be motivated by the knowledge that a specific lecture covers material directly relevant to a question posed in the examination. However, while this might be an effective means of getting students to attend the lecture and to concentrate, it could encourage surface learning if it merely provides an opportunity for students to regurgitate material. If deeper learning is to be encouraged, then students would need to know that the form of the assessment will require them to apply, rather than reproduce, the understanding gained through the lecture.

4 Evaluating your lecture

Most universities have systems of formal student evaluation of lectures, involving some form of questionnaire. Sometimes these simply involve students scoring particular aspects of the lectures, such as clarity, pace and relevance. Sometimes they give the opportunity for students to make comments, and sometimes both. If these are to be used to allow you to make improvements to your lecturing, it is important first to establish what that the questions are seeking to evaluate and what assumptions are being made. For example, the questions may focus largely or wholly on you as a 'performer', rather than on the student learning experience. A lecturer may be very entertaining and popular with students, but that does not necessarily mean that lectures have been effective in terms of student learning.

If the most effective form of lecture is one where the students are actively learning during and after the lecture, then evaluation questions should reflect this. Students may prefer lectures that allow them to get a clear set of notes which are relevant to their formal assessment. As discussed above, some students prefer to be 'passive learners' and may resent lectures that are challenging in terms of material and activities.

The formal student questionnaire is only one means of evaluating your lecture and gaining useful feedback. This section reviews other methods of evaluating the success of a lecture programme.

Self-evaluation: judged against criteria

One of the most valuable means of evaluating your lectures is to reflect on what you are planning to do or have done in terms of student learning objectives. Before the lecture you might consider the following:

- What do you want students to get from the lecture?
- How will the lecture achieve this?
- Are you planning to cover the right amount of material given the abilities, experience and motivation of the students?
- Are there any other better ways of organising your material?
- Are the examples appropriate?
- Are visual aids clear and the right length? How could they be improved?
- What activities for students are planned? What do you want students to gain from these activities?
- How will the materials you provide to students complement the lecture? Will they encourage or discourage attendance and attention?
- How will the lecture be related to assessment?

This list is by no means exhaustive but it does illustrate the importance of reflecting on the links between what you are planning to do and what the students will actually do and learn (as opposed to what you would like them to). After the lecture, it is important to reflect on what you believe students have learnt and whether you could improve on delivery, content and student activity. It is vitally important to be realistic and not to believe that just because you have said something that the student will have understood it. Try to honestly judge what you have achieved in terms of the learning objectives you have set. While self-evaluation is important, this should ideally be backed up with more objective forms of evaluation.

Feedback during the lecture

If you are brave, you could ask the students periodically to judge your lecture against some clear criteria. This could be in the form of multiple-choice questions, perhaps using coloured cards or a Personal Response System (see Case Study 4). This allows students to 'vote' on various aspects of the lecture and the results are instantly displayed for you and the students to see. A less threatening alternative is to ask students to complete short question slips and to deposit these in a box at the end of the lecture. These could be questions about specific aspects of the lecture, or they could be more general. For example, you could ask students to name two things they liked about the lecture, two things they found difficult and two ways in which the lecture could be improved.

It is best to avoid asking students to comment orally on aspects of the lecture, unless the group is small and the students feel very comfortable to state that they are having problems. Whilst traditional forms of lecturing usually include some means of asking students orally whether they have understood, this is normally a waste of time as they will generally prefer not to respond.

Feedback after the lecture

If you are using a Virtual Learning Environment (VLE), such as Blackboard or WebCT, you could set up a discussion board inviting comments on the lecture. You could arrange this in sections. For example, students could be asked to identify topics they have not understood, questions they would like to ask, and discussions to which they would like to contribute. You could have a section devoted purely to general feedback on the lectures. You could have an FAQ section, where you post the answers on the strict understanding that if a student asks a question, you will answer it only if you have not already answered the same question (or very similar) from another student. As well as providing useful feedback for improving the quality of your lectures such a system supports students' learning.

If you do not have access to a VLE an email list can serve the same function. You could also use email if you want students to be able to comment to you privately. Alternatively, you could ask students to submit written comments on the lecture and then come to see you personally to discuss their comments. Provided this is set up in a spirit of being mutually

helpful, it could be a very useful and a profitable use of the office hours system. Alternatively, some time could be set aside in seminars to discuss these comments.

Peer observation

Many departments have instituted a formal system of peer observation of teaching as part of an appraisal system. Others use it as a confidential and more informal form of staff development. If it is used to enhance teaching, rather than merely judging performance, it can play a very valuable role in improving student learning from classes. A pairing system, where the two lecturers take it in turns to be observer and observed, can be a relatively unthreatening process and a very useful means of finding out how to improve your lecturing skills. This is especially so if the process is carefully structured, with prior discussion of learning objectives between observer and observed. The action of observing and giving feedback can be as instructive as the feedback from being observed. There is a danger, however, that the partners merely reinforce each other's prejudices. For this reason, it is normally good practice to rotate partners and also to provide some staff development activity in observing and giving feedback.

5 Case Studies

Case Study 1: 21st Century Engineering with Historical Perspective

Study Author: Liz Willis, Project Officer, Engineering Subject Centre

Tutor in Study: Gary Lock, Department of Mechanical Engineering, University of Bath

Subject Area: Fluid Mechanics

Study Completed: February 2005

This Case Study has been developed from data gathered through a demonstration of the teaching and learning materials available, interviews with the tutor, student questionnaires and focus group.

Background

Fluid Mechanics with Historical Perspective is part of a series of modules covering the broader subject of thermodynamics at the University of Bath. At the start of each hour long lecture the tutor gives a 15-minute input on an aspect of the discoveries and developments related to flight. This historical background usually consists of a five-minute PowerPoint presentation, followed by a short video clip providing the context for the formulae and calculations that are to be explained in the lecture. For example, at the start of a lecture on compressible flow of gases the presentation is on the story of the first supersonic flight. The tutor has developed 24 'mini history lectures' to accompany the lecture series which he hopes will make this largely theoretically-based subject more interesting for his students.

The lectures are supported by a set of notes given out at the beginning of each topic. The notes include visual images as well as brief notes on the historical perspective shown and the theoretical concepts explored. The notes are not, however, complete and students are expected to bring them to the lecture each week to *"fill in the blanks"*.

Students from all disciplines in the department, which include mechanical, aerospace, automotive and manufacturing engineering, are taught together in their first and second years, therefore there are approximately 150 students studying thermodynamics. This module is taught over 24 lectures in semester 2 and supported by weekly tutorial sessions. The department prides itself on the high mathematical content of its degree courses and all students are required to have studied maths and physics at A-level.

Reasons for introducing this teaching method

As the tutor is enthusiastic about the subject he enjoyed developing the new material for the lectures. A large collection of materials has been developed over a period of time and improved access to resources via the World Wide Web has helped to develop the library further. *"Remembering back to the lectures that I enjoyed at university, I wanted to add something interesting to these lectures".*

Students traditionally regard mathematically based subjects as difficult. The tutor aims to expose students to the *"colourful history"* of engineering through the use of videos and images in the lectures and it is hoped that seeing real applications will help students to understand the fundamentals of the science and mathematics being taught.

Students' perspective

Overall the students felt that the inclusion of the historical examples made the course more interesting and welcomed the inclusion of *"real examples of theory in action"* making the theoretical elements *"easier to understand"*. They felt more motivated and were keen to learn because they had more interest in the subject. Students noted that the *"turnout seems better in this module than some others".* Just 12% of the class felt that more time should be spent on core theory, with others requesting more videos to be included and more *"descriptions of the theory in physical terms"*, possibly developing the inputs to also include some examples of more recent developments. Students also commented on the lectures expanding *"beyond just engineering into social and political issues",* with the tutor being happy to discuss the impact of engineering on society.

Students appreciated the clear structure to the lectures. "There was a fundamental structure to everything that he did, and you knew that each lecture was going to have a certain amount of learning and a certain amount of putting things into perspective". They also felt that the course had been developed so that new theory was introduced evenly throughout the lectures and that their knowledge was built up over time. The students who attended the focus group highlighted the appropriate pace as a significant benefit and would welcome better pace and structure in other modules, even where videos and images were not available.

The tutor produced *"good quality notes"* that were seen as a *"really good read"*. Students thought that the gaps in the notes made them concentrate in the lectures. The reference sections in the notes helped if they wanted to learn more or go back over theory and, as the notes were illustrated with pictures and anecdotes, the students were more likely to read through them again. Students commented, "*the notes were structured and up to date – so many times we have notes which don't match the lecture because something has changed since last year."*

Issues

This year has seen the introduction of PowerPoint to deliver the lecture and this has proven useful in keeping the lectures and notes up to date. The tutor has won several university teaching prizes and has used the small cash prizes to fund a laptop to run the presentations and to pay for a student's time to source appropriate electronic images and videos. Some videos and images are covered by copyright and it can take longer to find freely re-useable media. Using different types of media in the lectures can also mean that additional AV equipment has to be booked in advance.

Some of the students commented on occasional problems with the AV or the reproduction quality of some the videos and images and thought that this could be improved to avoid loss of lecture time.

Benefits

Overall the students thought that they remembered more of the material because the theory had been given relevance. *"I remember the dimples on the golf ball and how the cricket ball travels and stuff. I remember that from the first lecture."* The students seemed to have engaged more with the teaching and commented that lectures had *"inspired conversation afterwards with friends."* They had also been able to use the theory in other areas: *"The nice thing about that as well is when you are doing other courses, when you're doing concepts and things, it has stuck in your mind so you can bring it up."*

The tutor is an aerospace engineer so many of the examples used are about the history of flight, and it is hoped that students who might not previously have thought of opting to take aerospace engineering at the end of the 2nd year may now consider the subject because they are more aware of the some of the achievements of the discipline.

Reflections

Large class numbers can make it difficult to motivate and enthuse students due to the lack of individual contact. The tutor has encouraged students to complete the student feedback questionnaires distributed at the end of the module and prides himself on how well this simple approach is received by the students. "It has achieved what I'd hoped because I am still as enthusiastic and excited about a lecture as I was when I began. I still get a buzz, especially from a big class."

The students commented that the tutor was "clearly enthusiastic about the subject" which in itself improved the lecture and they appreciated the extra effort the tutor had gone to: "I look forward to these lectures!"; "The best lecture series I've had. Makes me want to do the work!"

Case Study 2: Use of Skeletal Notes to Increase Interaction with Students in Systems and Control Engineering Teaching

Diane Rossiter, Learning Development and Media Unit, University of Sheffield

Presented is a brief outline of experience over 10 years or so of using the so-called skeletal notes approach within systems and control engineering teaching. Skeletal notes are such that the students are provided with an incomplete set of lecture notes and are required during the lectures to "fill in the blanks". The purpose being that by missing out key points in the notes the students are expected to remain active learners within the lecture. Also, using these type of notes lends itself more readily to incorporating interaction between the lecturer and the students. Two sets of data from end-of-module questionnaires are used to provide evidence that adopting this type of lecturing style can help the lecturer be well prepared and an effective teacher as well as helping the students participate more actively in their learning thus develop a good understanding of the subject.

Background

When I first started teaching in 1992 I wanted a lecturing approach that would get the students to engage actively in the learning process and give myself the opportunity to interact with the students rather than just spending the time writing out notes to be copied down. I was introduced to skeletal notes by an academic friend [1]. This is now a widely accepted approach and nowadays is typically taught to new lecturers as part of their teaching and learning induction programme [2].

Methodology

The skeletal notes approach adopted has been found to be effective - the students like not having to copy a complete set of notes and some appreciate the opportunity to interact within the lectures. The method has been used with small (30 students) and large (120 students) groups to almost equal effect. It has been seen that as the weeks of the courses pass the students seem to engage more fully in the lectures and respond to questions!

The preparation required by the lecturer involves:

1. preparation of a full set of lecture notes;
2. decisions about which are the key points and where the gaps are to appear in the lecture notes for the student handouts, then preparation of the handouts;
3. preparation of the OHTs and the script for the lecture (including any ideas for interacting with the students);
4. provision of copies of the skeletal notes to the students (followed by making available copies of the completed notes a week or so after the lecture, if required).

The students do not need any special equipment, just a pen! The lecturer needs to ensure the lecture theatre is suitably equipped.

The use of the skeletal notes approach has been used in most of the author's teaching, including employment as a lecturer (firstly at University of Exeter 1992-95 and then at Loughborough University 1996-2001) and later as a freelance lecturer. Presented below are two sets of data from two courses delivered for the Department of Chemical Engineering at Loughborough University.

Issues

The key issues are:

1. It is possible to get through a large amount of material very quickly and lose the students in the process! Hence, it is important to interact with the audience to check whether they have grasped the material so far before continuing. The interactions need to be at a basic level otherwise the majority of the students may be demotivated. It is important to "carry the majority forward" not just the bright few!
2. There is a need to be aware that more interaction during the lectures can lead to some students becoming less inhibited as they perceive they are becoming more familiar with the lecturer. Any disruptive behaviour needs to be dealt with swiftly to prevent chaos breaking out! (this has been achieved by having a zero-tolerance approach.)

Possible barriers are: the personality of the lecturer needs to be such that they can be responsive to feedback during the lectures and be aware of when students become less engaged and stimulate them. Also, it is important not to feel constrained by the highly structured notes. If expansion on the notes is required to make a point more clearly, then the students can be asked to write some additional notes from the blackboard to "break up" the format of the lecture and keep them engaged.

Benefits

The benefits observed are:

1. The students are able to engage more actively in the lectures.
2. The lecturer is able to gauge where the students are experiencing difficulties at the earliest opportunity by getting their feedback during the lectures.
3. The lecturer-students relationship becomes more effective as the students gain confidence in answering/asking questions during the lectures.
4. The lecturer provides a well-ordered/structured set of basic lecture notes for the students to learn/revise from and expand on.

Evidence of Success

The following data is taken from end-of-module student questionnaires for two course, where neither questionnaire directly asked about the skeletal notes. The first, a final year Process Control module (1996/97) where the author team taught up to 50% of the lectures, received a

total 44 responses and of those 8 students chose to make the effort to comment that they liked the skeletal notes approach. 88% thought the course was well prepared (9% neutral, 3% negative) and 67% found the teaching aids used helpful (30% neutral, 3% negative). It is believed that this feedback indirectly relates to the lecturing style i.e. the skeletal notes approach. 81% thought the author was an effective teacher (16% neutral, 3% negative), which could relate to the use of interaction to engage the students more fully in the learning process. The module leader, who summarised the feedback data, recommended to the departmental teaching committee that the skeletal notes approach should be adopted more widely within the department.

The second course, a computer software course (1999/00), was taught solely by the author and was less mathematical in nature than the first. 43 students responded, 92% thought the course was well prepared (8% neutral) and 79% found the teaching aids helpful (21% neutral). 84% thought the author was an effective teacher (13% neutral, 3% negative). The students were also asked to comment on whether the way the module was delivered had encouraged them to participate - 69% positive, 24% neutral, 7% negative. However, when asked whether the module had given them a good understanding of the subject - 83% positive, 14% neutral, 2% negative. Overall, it is believed that this approach had been effective for the students' learning.

How Can Other Academics Reproduce This?

The preparation (see Methodology) for this approach can be reproduced with some practice by reflecting after the lectures on what did/didn't work and why. In the beginning, the interaction during the lectures needs to be "stage managed". But as the course progresses, hopefully the lecturer gains confidence and familiarity with the students and becomes more spontaneous with the interaction.

Reflections

Systems and control engineering is considered by most students as highly mathematical, challenging and difficult. By using skeletal notes and incorporating interaction within the lectures, it was possible to engage the students more fully and identify issues at the earliest opportunity. Observing students grow in confidence over the course and become excited by the subject, rather than demoralised and switched off, was a great reward. The evidence presented is weak compared with what may be obtained via a more comprehensive evaluation study. However, it is felt that this evidence indicates that using skeletal notes had a positive impact on the learning of the majority of students in those courses.

References

1. Woodgate, KG. 1992. Lecture and student notes on state space control, Imperial College, Aeronautics Department, South Kensington, London, UK.
(Dr. Woodgate had been an undergraduate at Imperial College in the 80's. He had been taught by Dr. John Allwright who apparently had used the so-called skeletal lecture notes approach. Due to a severe speech impediment, he used a tape recording of his voice to deliver the lecture.)
2. Jackson, D. 2004. Large Group Teaching Module, The Certificate in Learning and Teaching (CiLT) Participant Handbook 2004/05, LDMU & School of Education, The University of Sheffield, Sheffield, UK.

Case Study 3: A Game Show Format for First Year Problem Classes in Mathematical Modelling

Colin Thomas, School of Engineering, University of Birmingham

Problem classes are traditionally used in the teaching of mathematics. For a first year Chemical Engineering course in mathematical modelling, a quiz based on the TV programme "Who Wants to Be a Millionaire?" has been introduced in a problem class supporting lectures. Following group work, with one set problem per group, students present their solutions to the rest of the class. The quiz follows the presentations. Each group is represented by a volunteer who attempts to win chocolate prizes. The questions are both general and specific to the particular problem done by the group. Besides reinforcing earlier learning, the quiz is fun. Certainly it appears to have been appreciated by two successive student cohorts. The lecturer and postgraduate demonstrator have also enjoyed the problem classes more than traditional formats.

Background

This modelling sub-module consists of 13 lectures, and two two-hour problem classes. A highly structured approach to modelling is taught in the lectures, with a strong emphasis on the key issue of 'how does one begin?' Students usually struggle to turn a problem expressed through words into mathematical equations and the method given to them is almost formulaic. Many examples of modelling are presented. These are taken from chemical and biochemical engineering practice and there are some of broader interest (e.g. mathematical ecology). The engineering context is never allowed to overwhelm the modelling and is often simplified and always explained. Detailed notes are provided in the lectures.

Methodology

The problem classes are intended to provide practice at modelling and in solving the resulting equations. The problem classes occur on (separate) afternoons in the second term. Both involve 25 to 30 students and each is repeated as the whole cohort is 55 to 60 students. The first problem class emphasises the development of models, beginning with the students criticising an attempt at "modelling" from a Tom and Jerry cartoon (a short video clip from which is used as light relief in an earlier lecture). The second problem class begins with more difficult model building involving second order ODEs and the quiz finishes this problem class.

In order to break up cliques and promote better interpersonal skills (i.e. team work), the students are allocated at random to one of four groups as they arrive. There are seven to eight students per group. The first 50 minutes of the second problem class is group work on one of four set problems, resulting in the preparation of a few overhead transparencies

explaining the group's problem and its solution. The author and a postgraduate demonstrator circulate around the groups giving advice. Strong students are asked to help weaker students so that all group members understand the group solution (and more interpersonal skills are practised). After a short break, one student volunteer from each group presents to the whole class (four lots of five minutes). Originally it was conceived that any student might be asked to present, but compulsion was replaced by the offer of a reward - the volunteer receives a large chocolate bar. It is certainly the case that presenting complex mathematical derivations on a few overheads and in a few minutes makes a student have some sympathy with the lecturer!

After the presentations, the "*Who Wants to be a Modeller?*" quiz begins. A second volunteer from each group faces six questions related to his or her group's problem. Four answers are given with every question. These are shown on an overhead projector to the student (who comes to the front of the room) and the rest of the class. Typically one answer will be correct, one will be obviously wrong, and the other two contain typical student errors. The student must choose one. As in the TV show the student has 'lifelines': "p*hone a friend*" becomes ask a specific group member, "*ask the audience*" means ask the class, and "*50:50*" works by the author removing two answers (not necessarily at random; a struggling student might be left with the correct answer and an obviously wrong one, whilst a stronger student might be left to choose between the correct answer and a common trap). The rewards for correct responses are chocolate bars, of the small party pack variety, for later distribution to the group. Unlike the TV show, one cannot lose everything: one correct answer overall is rewarded with one bar; two answers correct, two bars; three correct, four bars; up to six correct answers, 32 bars! The first question is always a joke (e.g. .Which of the following is a great model? Prof. Thomas, Kate Moss, a Skoda, La-La - cheesy but gets things going in a non-threatening way!).

The questions are such that it is hard not to get at least five correct. When appropriate, discussion of the incorrect choices and the traps follows a question, using a whiteboard for notes when necessary. The four quizzes take about 40 minutes, completing a two-hour class.

Issues

Volunteers are usually difficult to find, but chocolate seems to be sufficiently attractive. The volunteers are usually the better/more confident students, but the quiz is sufficiently stimulating to keep everyone's attention. If the groups were smaller, and there was a facilitator added to each group, no student could 'hide'. However, this would require much more demonstrating effort and if every group presented a solution, the problem class would become too long. The chocolate costs about £10-15.

Benefits

The problem classes mix several elements This, and of course the quiz itself, keep student interest high. Chocolate is an acceptable reward and is key to the exercise! All of the proceedings are very informal, and essentially non-threatening, which helps improve participation.

Evidence of Success

Attendance at the problem classes is nearly 100%, and rarely does anyone leave before the end. Students have sometimes asked if they can attend the repeat of a problem class they have attended! The interactions between students and between students and staff are at a high level throughout. Student feedback is positive (leaving aside the obvious "*What was best about the course?*" - "*The chocolate*".). The quality of answers to the assessed coursework (which follows the problem classes) has improved significantly. The author and demonstrator have both enjoyed the problem classes, more than for previous traditional approaches.

How Can Other Academics Reproduce This?

The methods are simple and should be easily reproduced by anyone who has seen the TV show. Alternatively other TV game show formats could also be used in learning and teaching.. The game show (quiz) format could be applied in other mathematical problem classes or problem classes in many subject areas.

Case Study 4: New Approaches to Teaching and Learning in Engineering at the University of Strathclyde

Geoff McKay, Department of Mathematics, University of Strathclyde

Mathematics is perceived as a difficult subject within engineering or science degree courses. Traditional lectures, with students passively listening to the lecturer or transcribing notes, do little for the students' image of mathematics. This style of lecturing and its lack of feedback can also be very unsatisfactory for the lecturer. In an attempt to overcome these problems, an element of interaction has been introduced into lectures. This has been achieved by encouraging communication via the Personal Response System, part of the Interactive Classroom developed by the Department of Mechanical Engineering at the University of Strathclyde (see Case Study 5). Lectures are problem-based, with students immediately given the opportunity to put the methods they have learnt into practice.

Background

Traditionally, students on science or engineering degree courses struggle with the mathematical element of their curriculum. Mathematics is perceived as a very *dry* subject, based on incomprehensible theory and applied to complicated problems. Too early in their degree courses students become de-motivated where mathematics is concerned. Attendance levels drop, students are unwilling to work through questions on their own and, as a result, performance levels suffer. In order to counter this the Department of Mathematics successfully undertook an overhaul of its service-teaching provision.

Methodology

As part of its overhaul of service-teaching provision the use of *theory notes* in all first year classes was investigated. In reality these notes contain little theory but cover in detail the methods introduced in the class. Lectures are no longer an exercise in dictation (many students struggle with dictation simply because of the teaching methods they are accustomed to from school or college). Students are given concise, accurate and focussed versions of the background material for each section of the class. They are not expected to copy theory from the board. Theory and methods are covered in a shorter period in class and consequently lecturers now have more time to demonstrate the important concepts via a series of relevant examples. By following these illustrations as they are developed in lectures (in conjunction with the clear theory notes), students are in a better position to attempt problems successfully on their own. The students respond well to this type of example-based teaching and their understanding has improved.

Another element of the teaching overhaul was the introduction of Class Tests. These Tests have proved highly successful in a number of ways. They act as an incentive to students to

maintain their work level, thereby gaining an exemption from a longer end of semester exam. They also provide feedback to the student and lecturer on performance as the class progresses.

Whilst example-based teaching has certainly proved successful, the student still learns *passively*. All too easily the students leave the room but forget what they have learnt because they have not put it into practice. Rather than rely on the student making the effort outside the lecture it would be preferable for the student to attempt examples *during the lecture itself.*

Such a combination of lecture and tutorial has been introduced using a classroom communication system, the Personal Response System (PRS). Students become familiar with PRS early in the Mechanical Engineering course at Strathclyde, and employ it in many engineering classes. This has been extended to include Mathematics in the first year. Students are allocated a PRS handset with a unique ID identifier. They are also assigned to groups of four students that they remain in throughout the semester.

During lectures, students are asked to work through examples based on material recently covered by the lecturer. They are encouraged to do this within their groups, thereby using fellow group members as a learning resource. Students are also given a number of possible answers to the problem, say, five choices. The PRS handsets are used to transmit the students. Responses and confidence levels are transmitted to the lecturer via receivers and PC software. The overall performance can be displayed graphically and discussed with the class. A similar approach is adopted in tutorials, although here the students are given a series of problems to work through and are encouraged to converse with individual tutors.

The choice of question set to the class is highly important. Sometimes this might be a snap question where an instant response is required and students are encouraged to recognise solutions or the appropriate approach without the need to resort to pen and paper or a calculator. Questions may also be broken up into smaller stages and the students can be asked to respond at each stage of the process. The use of distracters amongst the offered solutions is also very important. Every year students make the same simple mistakes. By providing possible answers based on typical mistakes, the lecturer can demonstrate errors common amongst students and help eliminate them.

To demonstrate this, the following are two simple questions used in class during the Differentiation Block. The first is a snap question where the student is expected to respond quickly. For the second question the student is allowed more time.

1. Differentiate $\cos(5x)$ with respect to x.

*Possible responses: -sin(5x), (-sin(5x))*5, (-sin(x))*5, -sin(5x*5), sin(5x)*5.*

2. If $x(t)=\cos(t)$ and $y(t)=\sin(t)$, then calculate $d2y/dx2$.

Possible responses: -cosec3(t), -cosec2(t), -cosec(t), -cos2(t), -cos(t).

Other course materials may be found at

www.maths.strath.ac.uk/coursemats/MA115/

Issues

Following several years experimenting with PRS handsets in tutorials, the Department of Mathematics made the decision to employ this type of teaching in lectures. However, the major barrier to this was organisational. The recently refurbished NATALIE rooms at Strathclyde are in high demand and the course in Mechanical Engineering is also extremely popular. It proved difficult to timetable the students in the appropriate rooms which were either in use or not large enough for the Mechanical Engineering cohort. These restrictions may also prove significant in determining whether we can extend the methods to other cohorts of students.

Providing lecture notes for all students in service teaching classes is an expensive undertaking. There is considerable staff effort required in producing high quality notes, exercises, solutions, lecture slides, relevant examples, etc. Similarly, the financial implications of photocopying many copies of theory notes are considerable.

Thankfully, we have not had to overcome any resistance to innovative teaching methods within the University, although passive learning still dominates in too many areas of teaching.

Benefits

Students were encouraged at a very early stage to discuss their work within groups or with the lecturer. The confidence gained by successfully attempting problems in the lecture, and the instant feedback provided by the lecturer, helps the learning process.

Therefore the benefits of the PRS system are many-fold:

- It promotes student activity/discussion within a class.
- It provides immediate feedback to the students and helps them gauge their performance within the class. Assignments have also been constructed for the students based on multiple choice answers. Again, selections can be transmitted to the lecturer using handsets and immediate feedback given to the student.
- It also provides an immediate response for the lecturer. More time can be devoted to a concept when the students perform badly. Alternatively, by storing the responses from each lecture in a file, the lecturer can analyse a student's performance

throughout the whole year. Class attendance can also be monitored in a similar fashion.
- Students are more confident about mathematics and methods have become more familiar.
- By interrupting the elongated teaching slot the questions set in class and subsequent discussions help maintain student interest and concentration.

Evidence of Success

As part of the NATALIE project education specialists at Strathclyde have interviewed students. Their views on this type of teaching (in mathematics and engineering) have been extremely positive. Questionnaires completed by the students also provide positive responses (interestingly, many students requested that even more use be made of the handsets in mathematics lectures). Overall the performance of the cohort examined here (in Class Tests or exams) is extremely high compared with students studying the same material but not exposed to the interactive teaching approach (it should be pointed out, however, that Mechanical Engineering has higher entry requirements than most courses within the Engineering Faculty at Strathclyde).

How Can Other Academics Reproduce This?

Theory notes with examples carried out by the lecturer have proved very successful at Strathclyde for a number of mathematics classes, even without student interaction. However, using the PRS allows the lecturer to involve the student more actively in the learning process.

The approach described here is essentially a mix of tutorial and lecture. It could be employed in a variety of mathematics classes, although perhaps it is more suited to lower level material or problem-based subjects (e.g. mechanics). However, without some form of student monitoring, it may prove unsatisfactory. Without a response system some students will inevitably 'hide' (especially if student numbers are large), choosing to put in no effort in class. The PRS system, whilst providing feedback and although not foolproof, is a valuable tool for overseeing student effort and performance.

References:

EduCue (PRS distributor): http://www.educue.com

Case Study 5: Large Scale Introduction of Active and Collaborative Learning in Lectures

Professor Jim Boyle, Department of Mechanical Engineering, the University of Strathclyde

In 1997 the Department of Mechanical Engineering in the University of Strathclyde embarked upon a radical change in its teaching methods for first year students.

The aim was to introduce active and collaborative learning in the large lecture room through the use of Peer Instruction, a version of Socratic Dialogue ("teaching by questioning") developed by Professor Eric Mazur of Harvard University. The standard lecture/tutorial/laboratory format of traditional instruction was replaced by a series of two-hour active-learning sessions involving short mini-lectures, videos, demonstrations and problem-solving all held together by classroom questioning and discussion. A custom built lecture theatre - the InterActive ClassRoom - was constructed in 1998 to enable this style of teaching. The Classroom - which holds 120 students - was designed for group seating, and, to assist Peer Instruction, included the first Classroom Feedback System (Classtalk) in Europe. Classtalk has now been replaced by the Personal Response System (PRS). Peer Instruction was initially used in Introductory Mechanics and Thermo-Fluids classes, but was quickly extended to include Mathematics. This accounted for half of the compulsory engineering elements of the first year.

The following year a version of Problem-Based Learning (Mechanical Dissection) was introduced into the Design classes. Now students work in groups of four in the design classes and also work together in the same groups in the InterActive ClassRoom. Finally, in 2000, the University of Strathclyde built the first of its new Teaching Clusters, a managed suite of teaching rooms that includes additional InterActive ClassRooms, seminar rooms and the first Teaching Studio in the UK. The Studio is based on a design developed by Rensselaer Polytechnic Institute in the US. The first year students now use the Studio for Engineering Analysis classes and their learning experience is a mix of Peer Instruction, Problem-Based Learning and Studio Teaching.

Overall, the change to active teaching styles, with collaborative learning, has been a huge success, both in terms of student performance and retention. An independent evaluation was carried out a couple of years ago [1] and it's probably best to let the students speak for themselves:

" … with 100 people in the class you normally just sit there without being involved... and add to your notes. In that class everybody's involved, you have to think about what's being said...you have to stay awake...but it's more fun, you get more from it...better than just sitting taking notes …"

"…what fun it can be, it can be light-hearted yet you still learn a lot …"

"… how quickly a two-hour class passed compared to other one-hour lecture classes …"

"… think you can learn a lot easier from the people that are the same age as you...if they've just grasped it then they can explain it in sort of easier terms than the lecturer...you suddenly understand it when a minute before it was difficult …"

Further information can be found in a video interview given at the Hong Kong University of Technology:

http://celt.ust.hk/seminar/jim_boyle/

and in a forthcoming JISC video, which will be part of the ***Innovative Practice with E-learning Project*** on active, collaborative learning with handheld technology.

Reference:

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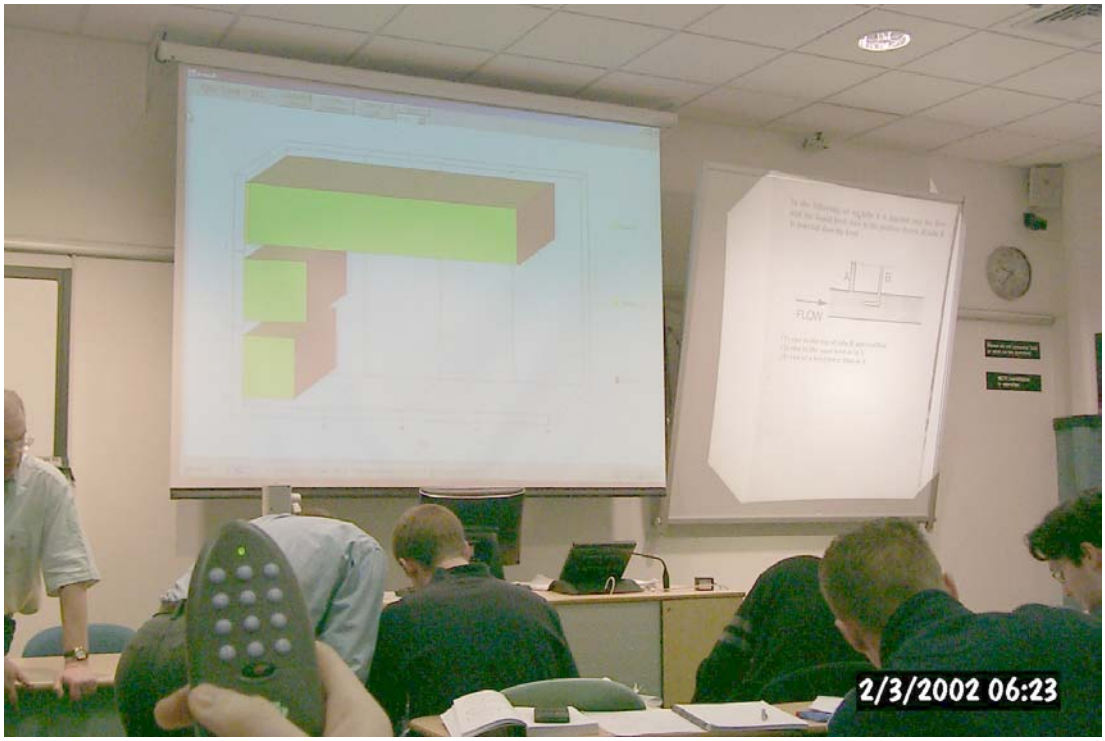
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6 Where next?

Suggested Reading

The majority of existing pedagogical research into the use of lecturing and student learning continues to be generic.

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Web Resources:

The Association of University Teachers submission to the government's comprehensive spending review, entitled *Reaching for 50% participation: sustainable growth in higher education*, is available online in the reports section at:

http://www.aut.org.uk/pandp/reports.html

The Center for Teaching and Learning at Stanford University has a section on Teaching Tips, Handouts and Links that includes a guide to Giving a Lecture at:

http://www.stanford.edu/dept/CTL/TA/

The Center for Teaching Development at the University of California, San Diego has a Teaching Assistant Handbook that is available at:

http://www.ctd.ucsd.edu/resources/tahandbook.pdf

The Effective Lecturing project, funded for one year by the Scottish Higher Education Funding Council, has a Web site featuring a number of video based case studies (requiring the freely available Quicktime software) and three excellent papers on What is the Use of Lectures?, Good Practice in Lecturing and Use of C& IT in Supporting Lecturing. These are available at:

http://www.gla.ac.uk/services/tls/STAFF/ras/ELPwebpage/project/index.htm

Resources produced by Tony Buzan which may be of interested if you wish to follow up the idea of using ‘Mind-Maps’ may be located at

http://www.mind-map.com/

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