Meeting the growing demand for engineers and their educators: the potential for open and distance learning*

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Abstract

Many organisations and individuals already offer distance learning in science, engineering and technology (SET). Offerings range from on-line lecture notes or home-grown simulations to global multi-media programmes with high-quality student support.

There is, however, still a certain reluctance in some circles to accept that successful open and distance learning is possible in SET. Searching for 'engineering' in the courses and programs of one prestigious distance learning university in North America provokes the following response:

> As a distance education university, [we are] unable to offer courses in the area of engineering.

Yet experience has demonstrated very clearly that the delivery of such learning is indeed possible.

As with all teaching, open and distance approaches are successful only if based on good pedagogical design addressing the purpose, structure and pace of the material, hence engaging students and encouraging active learning. For distance learning such pedagogical design is often expensive, and can only be justified by comparatively large student numbers.

Much open and distance teaching offers meagre student support. To be successful, course developers must integrate student support into the learning materials, including such elements as a modest number of face-to-face sessions or electronic communication at a distance.

This presentation discusses these issues in the context of SET distance teaching and presents examples of good practice from the UKOU, including:

- an introductory course in ICT that adopts an issues-based approach, in order to de-mystify the subject and make it more attractive to students
- resource-based approaches in engineering education
- team projects at a distance
- an emphasis on 'active learning'

An argument is also to be made for the importance of *openness* if we really wish to promote engineering. In this context 'openness' means making programmes available to *all* students

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(even those without formal school-leaving qualifications) that will ultimately enable them to qualify as a professional engineer or an educator of engineers. The traditional approach to engineering education has been hierarchical and linear: a good school leaving certificate in mathematics / science followed by an often very theoretical university education plus an application-oriented final project. If we are serious about attracting new engineers, this will no longer do. An open and distance approach to engineering formation, based on outcomes rather than input educational levels, and with an emphasis on lifelong learning and professional development, can make a major contribution to change.

Introduction

The Open University of the United Kingdom (UKOU) was established in 1969 with the aim of providing higher education at a distance to all, including those without formal university entrance qualifications. At the time of writing this paper, the Faculty of Technology was one of nine OU academic units offering undergraduate and postgraduate courses. Most courses are of about 9 months duration, offered once or twice a year. Students are normally allocated to a local group of about 20 students and one tutor, for limited face-to-face or electronic tutorials plus informal support. This contact time ranges from around 2 hours per week for certain level 1 (first-year university) courses to as little as 12 hours or less per *year* at level 3 (final undergraduate year). Tutors mark students' written work, as well as providing them with other support and guidance. Course assessment is by a combination of tutor-marked assignments (TMAs), multiple-choice computer-marked assignments (CMAs), and a final examination or some other 'end of course assessment' (ECA).

The Faculty of Technology offers a number of programmes that can be categorised as 'engineering'. The Engineering Programme itself has around 2500 students studying part-time for a named BEng honours degree. Some other programmes too, are essentially engineering degrees or have a significant engineering component. The BSc (Hons) in ICT, for example, has a similar number of registered students.

The UKOU describes its own style of distance learning as 'supported open learning', whereby students study independently and at a distance but with extensive learning support available essentially on demand. The nature and level of support vary with academic level and subject but cover the full gamut of traditional and developing methods.

The Open and Distance Learning Quality Council (http://www.odlqc.org.uk) says:

> Open and distance learning include any provision in which a significant element of the management of the provision is at the discretion of the learner, supported and facilitated by the provider.
>
> This ranges from traditional correspondence courses, on-line provision and interactive CD ROMs, to open learning centres and face-to-face provision where a significant element of flexibility, self-study, and learning support is integral to the provision. [ODL QC, 2006]

It can be very productive to consider all engineering students (and indeed students of any other discipline) as in part studying by open learning. If we consider any parts of their notional learning hours that are not made up of face-to-face teaching as open learning, this prompts us to make suggestions and provide resources to support their open learning. Learners in a conventional setting can, in this way, benefit greatly from their teachers drawing on the expertise of the distance learning community.

The UK Engineering Professors' Council (EPC, 2000) profiles a graduate engineer in terms of their 'ability to' do certain things – the 'outcomes' of the degree programme:

1 exercise Key Skills in the completion of engineering-related tasks at a level implied by the benchmarks associated with the following statements

2 transform existing systems into conceptual models

3 transform conceptual models into determinable models

4 use determinable models to obtain system specifications in terms of parametric values

5 select optimum specifications and create physical models

6 apply the results from physical models to create real target systems

7 critically review real target systems and personal performance

It is our contention that all these outcomes can be delivered by open and distance learning. In the remainder of this paper we shall first explain what we believe to be the most important features of such learning. This section applies to all distance education, not just SET. We shall then present a number of examples of the UKOU approach to engineering education in courses developed and delivered by the Faculty of Technology. The examples presented are illustrative, not only of a much wider range of SET courses offered by the UKOU, but also of the huge potential for open and distance learning in the formation of professional engineers.

The basics of distance education

To be effective, distance learning needs to be:

- purposeful
- structured
- paced
- engaging

[Rowntree (1994), Endean (2003)]

Purpose comes from clear statements about the intentions and the end results of the programme of study – the 'learning outcomes' in current terminology (close to what were previously called 'aims and objectives'). To learn, all students, in what ever way, and in whatever context they are learning, need a sense of direction, of goals. They need answers to questions such as 'Where will this course take me?' and 'What will I be able to do at the end of it?' Clear and attractive statements of the aims and the intended learning outcomes of the course are necessary; not only for the course designers but also for the learners.

The intended learning outcomes of the course or programme should describe what the students should be able to do on successful completion. The level at which intended learning outcomes are set is of critical importance; they should be present at each level, from programme, where they are broad and will describe the high level engineering process, to individual 'learning object' level, where statements are needed about what learners can do in fine detail.

The ***structure*** of a learning module is of paramount importance in maintaining a learner's interest. Just as with purpose, the structure must be clear to the learners and this will allow them to exert some control over how they learn. Distance learners can feel extremely isolated and a feeling of control is a great boost to self confidence.

There are a number of ways of structuring ODL materials, each of which can be equally effective but each has its distinct advantages and disadvantages. The following brief list encompasses most options:

- teaching ‘narratives’, where the ‘narrative’ can be presented using a variety of media – from print to ICT-based techniques
- resources + commentary
- action guides + resources, including problem-based learning

Conventional teaching narratives for distance learners (whether traditional print or ICT-based), are constructed from scratch, involving significant commitment, time, trouble and, generally, expense.

An alternative is to use existing resources (printed or e-books, websites, journal articles, software, and so on) to cover the same ground. Such resources, however, are likely to be crucially deficient in many of the key attributes of ODL materials so must be accompanied by a narrative commentary. One major advantage of this approach is that it provides an opportunity to criticize the established view on a subject.

A different approach is to turn the narrative on its head. Given that effective learning involves doing things, a good way of generating learner-focussed learning materials is to set the learners one or more tasks and guide them to the sources of information they need to complete the task. Here the learner will be providing much of the narrative for themselves. This approach requires a significantly higher level of sophistication from both the learner and the provider.

Such a learning module could consist of:

- one or more case histories – focused on the subject area;
- a report outline – that learners are expected to complete about each case history and submit for assessment;
- a reading list – containing all the key information;
- an electronic discussion forum – where learners can work together to identify and pursue the key aspects of the problem, effectively constructing their own narrative.

This last approach highlights the fact that the structure adopted can depend as much on the abilities and stage of development of the learners as on what the provider hopes to achieve. A logical progression is from purpose-written narratives at entry level to more of a resource-based learning approach as learners near graduation.

Pacing is critical in distance learning. Without the discipline imposed by a timetable of events, learners can drift, fall seriously behind the recommended learning schedule and, without a truly pressing need to continue, will rarely pick things up again. Mostly the pressing need is some form of assessment, so here is one of the main techniques for pacing learners – deadlines! Assessment deadlines can be published in a study calendar which also provides an opportunity to suggest the overall pace of study expected from the learner.

Interaction, both learner-to-learner and learner-to-tutor, is another powerful method of ensuring learners maintain an appropriate pace, and judicious intervention by tutors can help motivate and encourage learners to keep going.

Purpose, structure and pacing are all essential aspects of distance learning provision but they can only be of limited value if the learner is not ***engaged*** in the experience of learning. Unlike the captive audience in a lecture theatre, there is actually nothing stopping the distance learner getting up and walking away when they lose interest. So serious effort has to be made to develop ways of engaging and motivating the learner. Some of the rules of engagement in distance learning are:

- ‘talk’ directly to the learner and address them as an individual. In Laurillard’s (2002) terms, engage them in a learning conversation. The learner should be ‘you’ (singular). The author should be ‘I’ and never ‘we’. The pronoun ‘we’ should be reserved exclusively for those occasions where both the author and the learner are involved;
- avoid the passive wherever possible as it distances the learner from what is going on.
- minimize the use of glib phrases such as ‘obviously’, ‘as you know’, ‘simply’ and so forth. For the learner to whom things are not obvious, already known or plainly simple this can be upsetting or confusing and, ultimately, alienating;
- use humour sparingly;
- take account of the diversity of the learners. This should not be a manifestation of political correctness but learners won’t all share the same cultural heritage so care should be taken over references which include assumptions about gender, race, language, history and so on.

These general principles have long been applied to UKOU teaching materials. Many specific examples, which are now offered as free resources to learners and teachers, can be found at: http://openlearn.open.ac.uk/. In the following sections five technology / engineering courses, representing all the levels offered by the University (undergraduate levels 1 – 3 and postgraduate) will be presented in outline, with an emphasis on some of their novel features. The aim is to demonstrate just what can be done in teaching engineering at a distance.

Level 1: *Networked Living*

This is an example of an introductory course using a student-friendly, issues-based approach with an emphasis on active learning right from the start.

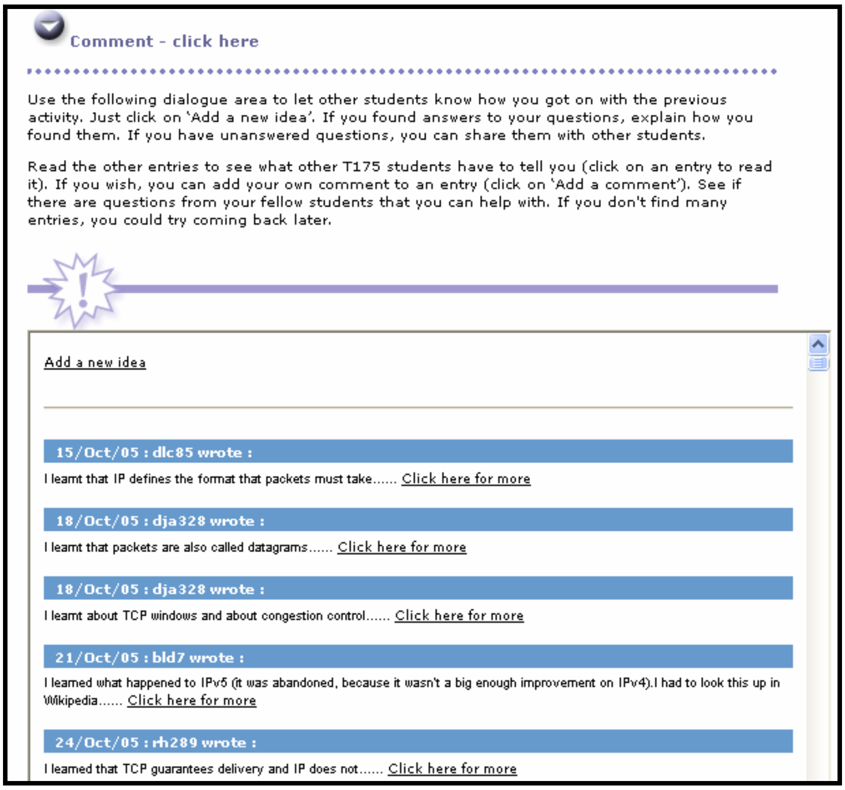
Background

Networked Living is a 300 hour, multiple media, distance learning course. The first presentation of the course, in 2005, attracted over 1600 students, and numbers are now running at around 3000 per year. The course introduces students to general concepts of information and communication technology in a range of contexts, by presenting issues in the areas of: communication and identity; entertainment and information; and health, transport and government. It is an introductory course included as either core or optional in a variety of bachelors’ degrees, including the BSc programmes in: *Information and Communication Technology*; *IT and Computing*; and *Technology*; as well as the BEng (Hons) engineering programme. The course was designed with a focus on retention of students and preparing them for further study. Student workload and pacing was carefully planned and there is a significant study skills component. The course uses a range of media, including: text, audio, computer animation and other software, and a website. Active learning is encouraged by means of activities, online quizzes, animations, spreadsheet construction and a learning journal. Continuous assessment is carried out via a mix of multiple-choice assignments (to test factual and numerical skills) and written assignments (which include elementary research into new topics). The course culminates with a written end-of-course assessment. This includes a major reflective component, as well as more traditional questions designed to test knowledge and understanding. For those interested in further details, see Bissell & Kear (2006). Here we shall concentrate on the features designed to encourage students to become active learners.

Active learning

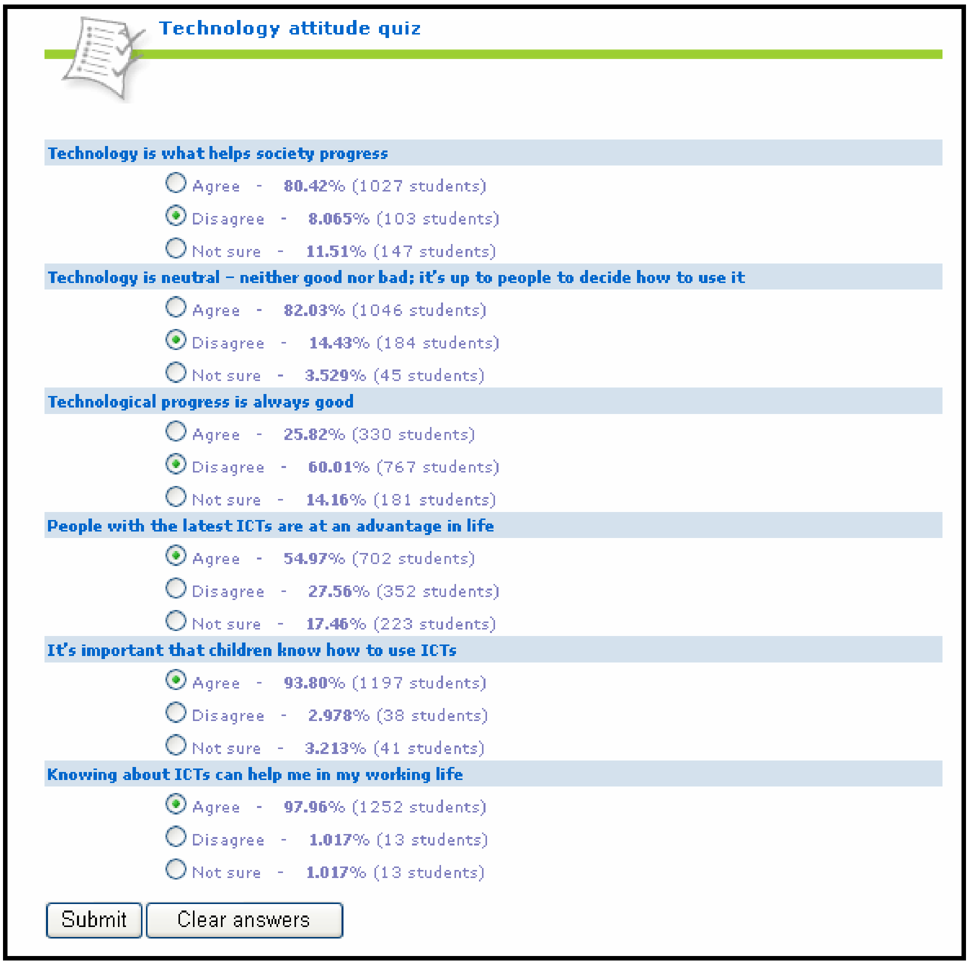
Open University students have always been encouraged to be active learners, with printed materials from the earliest days including 'self assessment questions' and various practical activities. *Networked Living* has built on this tradition, using current ICT tools. The course uses a great variety of activities to encourage active learning. In both the printed texts and the web pages, exploratory and self-assessment activities are used to help students to engage actively with the material. These activities are often combined with interactive online tasks. One type of the latter invites students to insert their own comments into the body of the teaching web pages, as illustrated in Figure 1. Other students can then view these and add their own responses to each comment.

Figure 1 An example of active learning: a comment section from the course's online teaching



Another interactive activity within the web pages asks students to complete a quiz on what they have just been studying; Figure 2 shows the first activity of this type, polling students for their general attitude towards technology. After completing such a quiz, students can be given the results of other students' responses so far.

Figure 2 An online quiz



A novel aspect of active learning in *Networked Living* is the online learning journal (for a general discussion of learning journals, see Moon, 1999). Students are encouraged to reflect upon their learning throughout the course, and to keep records. They can do this in any way they wish – from a handwritten log to a computer-based form. But they are also provided with a purpose-designed tool – the online journal – via the course website. Using the journal facility students can record their thoughts on their studies and attach work they have carried out for course activities. They can also choose to share their journal entries with their tutor and other students in their tutor-group.

Active learning also takes place through collaboration. In a distance learning course such as *Networked Living* collaboration usually needs to be mediated by technology, and this is where the Open University's computer conferencing system comes into its own. Each tutor-group, of around 15 students with one tutor, has its own computer conference. This provides a space for students to work together on course activities, discuss ideas from the course, and help each other with any problems. There is ample evidence, via informal feedback from students to tutors, and students' comments in the course computer conferences, that students appreciate the rich mix of active learning in the course. Some student reactions can be found in Bissell and Kear (2006) but one response to the teaching of the protocols TCP/IP was:

> *"Full marks to the Course Team for making this potentially 'dry' topic so interesting. The animations are fun but make the processes clear in a memorable way, as the two computers chat to each other across a virtual network! Activity 7 was a simple but*

inspired twist – not 'read this & make a note of what you learn from it' but 'read this & make a note of what you don't learn'! Then go & find out the answers to your ***own*** *questions – not some that the Course Team has thought up for you. Constructivist learning at its best! Sharing the outcome of this learning semi-anonymously via the course website's interactive area is a great touch too... invites short on-the-spot contributions, whereas a vague exhortation to go & discuss this in the Tutor Group probably wouldn't have much effect. I learned as much about online learning as about TCP/IP here."*

Assessment: action and reflection

Each of the four study blocks of *Networked Living* has a tutor-marked assignment (TMA). The TMAs test conceptual knowledge and understanding of the course materials, and often involve students in actively researching a new topic for themselves. In addition the TMAs include questions that require students to reflect on their learning and to comment on some aspect of this. All TMAs are submitted electronically, using a web-based in-house system. All but the first block also has a computer marked assignment (CMA). CMAs are used primarily to assess factual knowledge, numerical work, algebraic manipulation, and spreadsheet interpretation. The TMAs and CMAs together make up the continuous assessment component of the course, with the TMAs accounting for 85% of this component and the CMAs for 15%.

The end-of-course-assessment (ECA) provides the other assessment component, which is equally weighted with the continuous assessment. The ECA is a portfolio of work that requires students to: comment on their answer, and the feedback they received, to one of the TMAs; answer a number of new questions and carry out investigative activities to demonstrate the knowledge and skills they have developed; work with a published article about an ICT topic; and provide evidence from their work on course activities that they have achieved specific course learning outcomes.

Level 2: *Cisco Networking*

The course *Cisco Networking – Cisco Certified Network Associate* is an open and distance learning course that relies heavily on the use of existing materials developed outside the UKOU: the Cisco Academy Programme http://cisco.netacad.net/public/academy/About.html.

Background

The Cisco Networking Academy Program was launched in 1997 with the specific aim of providing students with the Internet technology skills essential for working within a global economy. Since then the program has been delivered to 1.6 million students in 150 Countries. The UKOU has so far successfully delivered the CCNA (Cisco Certified Network Associate) component to over 1000 undergraduate students. This is probably the largest delivery through a blended distance learning programme anywhere in the world. UKOU students gain University course credit by attending four day schools together with successfully completing a number of tutor-marked assignments and passing a final examination. By successfully completing Cisco's own assessment and examination they also acquire the industry-recognised qualification.

Novel student support

Two of the key features of the CCNA programme are the virtual learning environment (VLE) with its integrated assessment system and a remotely accessible laboratory called NetLab. The course is administered through an on-line gradebook based around a class. It allows students to take assessments at a pace that matches their study plans and provides immediate feedback once they have taken a Cisco assessment item. Tutors can also monitor how all of the students in their class are progressing, and use the results of their assessments to focus directed teaching.

The NetLab provides students with access to remote networking equipment to undertake laboratories. The system is self booking and allows tutors to work with student during labs and review students work. Together these technologies have provided distance teachers with a view of student progression that is closer to that experienced in the classroom. The success of the UKOU's *Cisco Networking* course is clear evidence that even 'hard' engineering education can be delivered at a distance.

Level 3: *Keeping Ahead in ICT*

Keeping ahead in ICT is another example of a distance learning course with a high resource-based component, this time as a means of keeping the course up-to-date, as well as delivering certain important generic skills necessary in engineering graduates. More details can be found in Bissell and Chapman (2007).

Background

Keeping ahead in ICT is a 300 hour, level 3 (final year undergraduate), distance learning course offered by the UK Open University for the first time in February 2007. It is aimed primarily at equipping students with advanced information searching and evaluation skills that will serve them well in professional life. Because ICTs are changing so fast, a traditional UKOU course with a great deal of printed material would be bound to date quickly. So there is much less print than in most OU courses, and a greater reliance on third-party resources.

The course consists of three, 100 hour blocks of study, increasingly relying on materials not written specially by the OU, such as newspaper, conference and journal articles, websites, and other electronic resources. Some elements in each block are designed to change from year to year, in order to retain currency. All blocks include an electronic 'companion', posted on the Moodle-based virtual learning environment (VLE), which contains advice on study patterns, and so on. The VLE is also used to post electronic versions of almost all print items, links to library resources, up-to-date news items, audio downloads, and any errata that may be necessary as the course proceeds.

The VLE also acts as a host to national and local electronic forums for discussion of course materials both with tutors and other students. Student 'self help' has always been considered a vital part of Open University study, and clear guidelines are given to students about the difference between valid self-help and inadmissible collusion or plagiarism.

Information search and evaluation

It is generally agreed that SET graduates must be sophisticated independent learners, able to locate and evaluate information for themselves. *Keeping ahead in ICT* includes an interactive tutorial (developed jointly with the Open University Library, and available both online and in a downloadable executable version via the VLE), which teaches the elements of the effective use of search engines, including such topics as the use of Boolean operators and specialist engines such as Google Scholar. Access to many commercial databases is provided via a Library portal, which obviates the need for additional passwords for databases to which the University subscribes. An important part of the tutorial is to compare the results returned by a generic search engine for a technical query with those supplied by a specialised database such as IEEE Xplore. All in all, UKOU students have electronic library facilities that compare favourably with the best of the UK conventional universities.

Other sources of information that are used, discussed and considered critically for ICT information searches include LexisNexis; electronic books; major national library catalogues such as those of the British Library and the US Library of Congress; commercial publishers' catalogues; and citation indexes. In each case the peculiarities and advantages and disadvantages of these sources are explained. Students are also introduced to the basic principles of copyright law and the *digital object identifier* (DOI) system for electronic resources.

By its very nature, the course requires students to carry out a significant number of on-line activities, so a broadband connection is advisable (although not strictly required). As part of these activities they evaluate electronic newsletters, blogs and wikis, as well as more conventional sources of information. An important feature of the teaching is to suggest structured ways in which students can make notes of information sources, including information (where available) about editorial policy, intended audience, possible bias, and so on.

Following the teaching of searching for information sources, students are introduced to techniques that can be applied to a detailed critique of what has been found, based on the detailed study of three articles on the topic of wireless sensor networks (WSNs).

Students practise extracting information from texts, but are also asked to think about the provenance of the materials, the background of the authors (including a Web search of their academic and other activities), and are asked to make judgments on the authority of texts. The emphasis in the teaching is to develop strategies for coping with new, complex ideas without panicking – and also to learn to make judgments about when it is appropriate to move on without having fully understood all the pre-existing text. This is a subtle and complex skill, and students often find it worrying. A number of examples are therefore included to illustrate how meaningful information can be gleaned from highly technical papers – particularly figures and diagrams – without necessarily fully understanding the complete mathematical derivation. This, in turn, raises questions of trust and authority, which are again problematic. A novel feature is the use of audio commentaries to guide students through their study of complex figures.

In addition to these generic skills, students also develop an advanced understanding of wireless techniques in current ICT systems in general, not only in the context of WSNs. They also look at a number of important issues in ICT, such as system failure and ICTs in the developing world.

Level 3: *Structural integrity*

The full title of this third level course is *Structural integrity: designing against failure*. The Course Team approached the subject from two directions: stress analysis and fracture mechanics, with both being copiously illustrated with real-world examples. The need for students to tackle real-world problems, and develop a set of skills that are immediately applicable in their working environments, is paramount within the course design and delivery.

Background

Structural integrity continues a long tradition of mechanical engineering courses from the UKOU that enable students to learn from detailed analysis of failed engineered components and systems, with the overall aim of designing more robust and reliable systems. Teaching through case studies is central to these courses, as is exposure of students to the standards and procedures in widespread use in industry. This is just one example of how that approach is realized within the course.

Learning from practice

The notion that undergraduates can learn some applied mechanics theory and then use it in the world of engineering practice is long gone. Validated computer code, which contains both theory and the experimental constraints that make such theory usable and applicable to complex geometries, is now normal in industry. Even grossly inadequate theories (as many are) can be made useful and useable in this way.

The question that needed to be addressed in *Structural integrity* was how to bridge the enormous gulf between the theory of fracture mechanics, and its practical implementation as a Failure Assessment Diagram (FAD). Such diagrams are at the heart of computer systems that can cost £10,000 per seat per year, and are essential to producing safety cases for critical engineering components containing cracks in service.

Labouring through theory based on line integrals that cannot be evaluated longhand, and then saying ‘nowadays this is all done by a computer’ seemed a touch lame. Furthermore, the theory is only useful for establishing that a particular crack is in an appropriate domain; it is the wealth of industrial data from experiment and field failures that produces a useful engineering tool. Equipping students with an industrial standard workstation is both unaffordable and, in any case, all the functions that it contains are hidden from users.

The FAD published in British Standard BS7910 has been in substantially the same form since 1986. It is essentially an envelope inside which an assessment point (produced by an analysis of a cracked body under stress) is safe, and outside which it is deemed to have failed. The proximity of an assessment point to the curve is a measure of the safety of the structure.

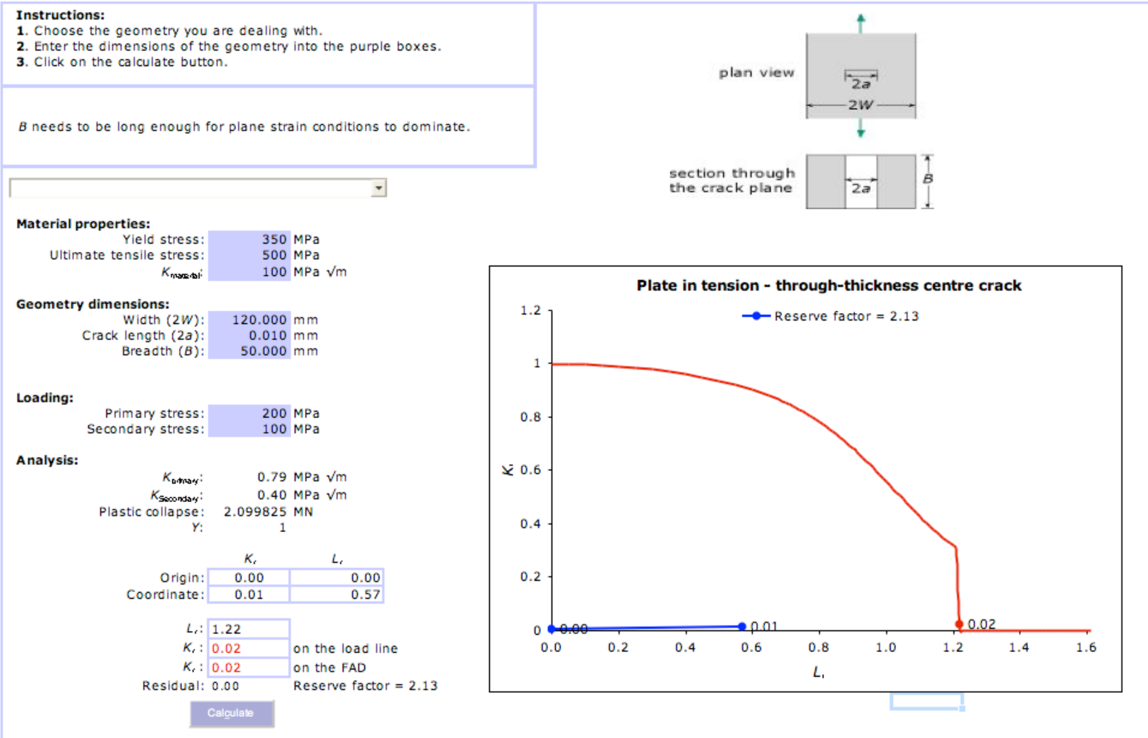
The solution the Course Team adopted to the problem was to accept the role of computer analysis *a priori* and teach only the physical principles of the theoretical limits that bound the FAD. They then described and commissioned a set of numerical experiments on standard, cracked geometries under different loads and on one common industrial problem. The curves produced demonstrated that the FAD curve was a good engineering approximation to a range of very different problems that grouped closely together.

It was then necessary to provide students with a working version of the tool that didn’t cost £10,000 and was easy to use. Because the curve is a simple fit to analysis and data it was easy to capture it in Excel™, which left the problem of how to create an assessment point.

Industrial practitioners use the results of analyses of standard geometries to analyse most common problems, and so an analytical facility was provided in the spreadsheet to choose geometries and loadings appropriate to a range of problems of the Course Team’s choosing. Using this spreadsheet an assessment point can be created, and its proximity to the curve calculated, without obscuring the principles.

The calculator that was produced (Figure 3) allows students to perform industrial standard safety cases in exactly the same way that occurs in industry. As the Course Team says to the students: ‘people earn their living this way’.

Figure 3 Failure Assessment Diagram calculator



Postgraduate level: *Team Engineering*

This final example of how the UKOU has approached engineering education at a distance illustrates in particular how distributed teamworking can be achieved. Because there is often scepticism about the feasibility of team work or group projects at a distance, we shall give rather more details about this course than the ones presented above. *Team engineering* was presented for the first time in October 2006 and what follows is an account of that first presentation.

Background

Team engineering was developed to deliver the following key skill learning outcomes to postgraduate engineering students in the context of conducting a design project in a team of four to seven.

> *On completion of the course, students will have demonstrated their ability to:*
>
> - *communicate effectively through written and spoken language with other group members during the project and in the presentation of the individual and group outcomes of the project;*
> - *develop, monitor and continually update a plan for the personal contribution to the group project;*
> - *negotiate, adopt, review and comment critically on the personal role taken within the group and exercise leadership within the role;*
> - *work effectively in a variety of roles as part of a team, exercising independence and leadership when appropriate.*

Team-working is almost universal across all engineering education but the challenges facing distance learners working in teams are substantial. Reams have been written on the formation of teams, team dynamics and working in teams, each of which can present difficulties even in a face-to-face environment. But it is at the first stage – team formation – that teams of distance learners most often founder. This is catered for in many instances by allowing individuals to complete the programme whether or not they are an effective operational member of a team. To deliver the learning outcomes above, however, *Team Engineering* students could not be given this option. If any team were to 'fail' *as a team*, the students would fail with it.

Team formation

The Course Team decided that the key to successful team formation was to maximize student participation and choice in the formation of the teams – this would help establish and maintain a team ethos by giving students 'ownership' of the resulting group. It was apparent that this was difficult, if not impossible to achieve at a distance, particularly within a realistic time frame. The most viable way of getting students to form themselves into teams was by face-to-face contact and interaction. The solution was, therefore, to undertake the team formation stage of the process at a residential weekend. Students help (and are helped) to form their project teams during the early stages of the residential weekend, as an integral part of a process which also selects one of the engineering projects on offer and allocates the team its tutor.

Having invested significant time and effort in becoming a member of a particular team, and having formed personal relationships with the other team members, each student leaves the first residential weekend with a real commitment to the success of the team. They undertake to participate fully in all of the team processes. The Course Team in turn undertakes to provide them with ICT support that makes their task as straightforward as possible.

Team-working at a distance

All Open University students have, for the last ten years, been provided with the email and asynchronous and synchronous communications tools that are part of the FirstClass™ suite from Centrinity as mentioned above. Now the University is migrating towards a more integrated virtual learning environment (VLE) developed using the OpenSource learning management system Moodle. Of the tools available within the VLE, the Course Team chose one in particular as having the potential to transform students' collaborative working – the wiki facility. In addition, they adopted a developmental system for lightweight video conferencing to facilitate synchronous communications within the teams. This is FlashMeeting (http://www.flashmeeting.com/).

VLE wikis

A wiki in its purest form is simply a webpage that anyone can edit at any time (see http://en.wikipedia.org/wiki/Wiki). With the added ability to restrict access to a wiki to specified people, any group of co-workers will find using a wiki a simple and straightforward way to produce reports and other documents to which several of them need to contribute.

Wikis are growing rapidly in popularity in educational communities because of the potential they offer for collaborative learning. But that was not the concern for *Team engineering*. The wiki simply provided somewhere each student team could gather together their work; a place where each of them could see what the others had been doing, that was not tied to a particular computer or geographical location, and that they had complete freedom to use in whatever fashion they found most beneficial.

Each team was therefore allocated a wiki to which all members of the team and their tutor had access. The Course Team also had access to all the wikis during this development phase so the students were aware that none of what they put in the wiki could be entirely 'confidential'. However, the principle was established that each team's work was not to be seen by other teams. All of the wikis were initially free of content or structure.

The teams used their wikis for a large range of different purposes including:

- meeting agendas
- meeting minutes
- project planning
- task allocations
- assignments
- assignment feedback (from the tutor)
- project journals

Many of these uses do not require the inputs of more than one person so it is interesting to see how the teams quickly started using the wiki space as a simple shared document repository.

The students encountered some technical difficulties. Most notably:

- the very crude wiki implementation in Moodle;
- the incorporation of images into wiki pages;
- the need to extract from the wiki the work that was to be submitted for assessment.

Being mature engineers, *Team Engineering* students are pragmatic people. They therefore found ways round these problems. But their 'workarounds' reduced their reliance on the wiki and they inevitably used it less than they would otherwise have. All of these difficulties are being addressed for second presentation of the course in the hope that the wikis will deliver their full potential.

FlashMeeting

The *Team engineering* Course Team felt it important to keep the students' team-working, as far as practicable, within the OU domain to avoid the chaos of 'small pieces' (Sclater, 2007). In reviewing the various options for synchronous communication to support their work, the developing FlashMeeting software presented itself as having the potential to make a valuable contribution to the toolbox for the students to use. In particular, FlashMeeting:

- relies on installation of nothing more than a Flash plugin, which is generally already installed on most personal computers;
- requires only simple hardware and network connection – a cheap webcam and a dialup connection work adequately (although broadband is better);
- provides 'one-to-many' voice and video channels;
- has no single 'point of control', allowing all participants equal status within a meeting;
- uses emoticons, voting and 'agree/disagree' icons for participants to express their views simultaneously and in real time;
- has a text chat facility
- archives all meetings in a form that allows outstandingly detailed analysis of the events of the meeting.

Each student was given a webcam at the first residential weekend and a very short briefing in how to set up and use FlashMeeting. Each team nominated one or more members to take responsibility for booking the meetings and went home from the weekend with their first meeting already booked. From then on, the Course Team had no further involvement in how the teams used the facility.

FlashMeeting was used regularly by the student teams throughout the course. One of the teams quickly established a protocol of twice-weekly meetings – one informal 'common room' type meeting and one formal meeting with an agenda and minutes. The other experienced some technical problems early on (two team members lived in Greece and one relied on a dialup network connection) and they came to rely less on the video conferencing abilities of the system. This second team therefore learnt to make use of a wider variety of communication methods but, nevertheless, still had regular FlashMeetings even if less frequently than the first team.

The students' continued use of the software was testament enough to its success in supporting their work. The minor technical shortcomings did little to dampen their enthusiasm for synchronous, face-to-face meetings:

> *"It's really good just to see everyone's faces. You see George light a cigarette or someone else leaves the room and comes back again with a cup of coffee. It feels like you're all together in the same place."*

The software encourages efficient meetings without stifling freedom of expression. And, crucially, the meetings are recorded to be referred back to later. This final feature adds a hugely important extra dimension to the usefulness of FlashMeeting in an educational context.

Following the end of a meeting, the original meeting url links through to the FlashMeeting archive (Figure 4). From there can be accessed a straightforward replay of the meeting with some very useful navigation tools (Figure 5) and a page of 'minutes' (Figure 6). These include a copy of the text chat from the meeting and a 'visualiser' or event map (Figure 7).

Figure 4: FlashMeeting archive screen dump

Figure 5: Meeting replay screen

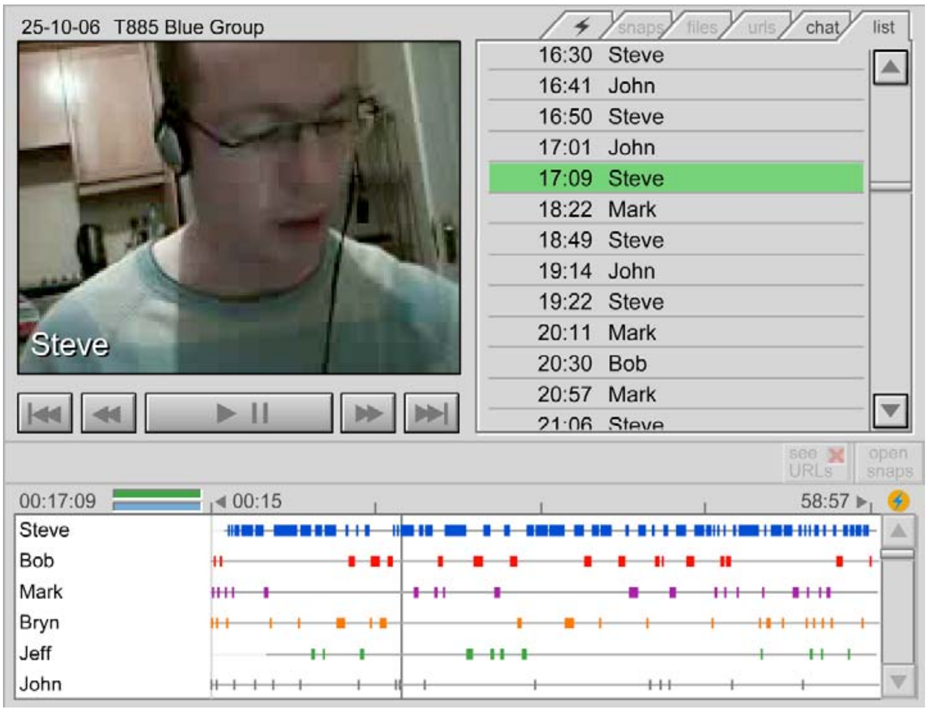


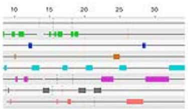
Figure 6: Meeting minutes

FlashMeeting

Meeting Minutes

T885 Blue Group
Meeting held 25-10-06 at 20:00:00 GMT +0100

Description:
Third meeting



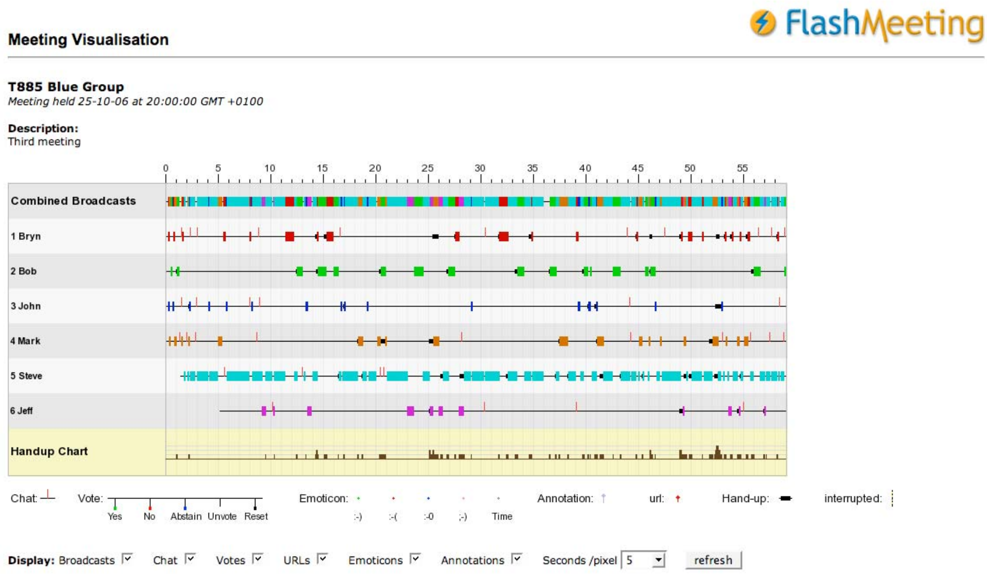
Meeting Visualisation

Attendees:
Bryn, Bob, John, Mark, Steve, Jeff.

Minutes:
No Annotations.

Chat Log:
01:23 Mark: Sounds good
01:32 Bryn: FIne by me
01:34 John: cool
02:00 Mark: Jeff
02:22 Bryn: No
02:54 Mark: Yeh lets go ahead
02:59 John: just go on.
03:03 Bryn: lets go
05:37 Steve: anyone else?
08:00 John: all ok with that..
08:40 Mark: Thats fine
08:53 Bryn: ok
08:55 John: ok
10:11 Jeff: ok
13:03 Steve: jeff and john do you want to jump in next
16:37 Bryn: so we just want to make lots of money
20:28 Steve: a little bit I'd say Mark!
20:47 Steve: we don't believe you bob!
28:11 Mark: That sounds good
30:20 Jeff: ok will do
30:26 Bryn: ok
39:05 Jeff: yes just read it looks good

Figure 7: Meeting visualiser



In a course where students are encouraged to reflect on their interactions with others and on the effectiveness of their and others' contributions to the team process, being able to look back over past team events is of critical importance. As one student put it:

> *"I've looked back at the recordings of meetings and thought: 'I could have handled that better' or 'I must make more of an effort to join in the discussion'."*

Tutors, too, are required to assess each team member's efforts and they can use the records of the meetings to help in that process. As one of the tutors wrote early in the first presentation of the course:

> *"I have to say that the combination of flash meetings and the [FirstClass] conference, with the wikis for archival material, is really powerful. I think that the Course Team have all but eradicated the distance barrier – the students have really latched onto this."*

Concluding remarks

We believe that in order to respond to the expected coming shortfall in qualified engineers we need to move away from the tired old models of engineering education. We shall not attract students by offering more of the same. If we are to increase the numbers of students choosing SET, and if we are to update existing teachers in high schools, colleges, and universities, we must make courses accessible, interesting and appropriately designed. This paper has discussed some of the fundamentals of distance learning, and given examples of teaching engineering at a distance from the UKOU. These examples have emphasised such features as: facilitating active learning; using issues-based and case-study approaches to motivate students; ways in which existing materials and even whole programmes (such as the Cisco materials) can be used for learning at a distance; ways in which students can be taught to become independent learners; and possibilities for postgraduate teamworking at a distance.

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