Open and Distance Learning for Engineering; Opportunities and Challenges

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Abstract

Purpose:
To describe an existing approach to open and distance learning opportunities and challenges for engineering in three particular areas, and discuss planned initiatives to improve the provision at the Open University.

Design/Methodology/Approach:
The majority of the ~4000 students currently studying for engineering qualifications with the Open University (OU) are mature students in full-time engineering related employment who study part-time through distance learning. This, together with the OU’s open access policy, results in a diverse student body and presents us with a range of challenges. The three areas considered are: the need to ensure that new students are adequately prepared for study at the required level; the challenge of facilitating and assessing group work effectively within a distance learning environment; the limitations of relying on generic mathematics modules not specifically tailored to engineering.

Findings:
Students’ previous educational qualifications have an impact on their likelihood of success at the Open University which operates an open access policy, enabling students with no formal academic entry qualifications on a programme of study. This makes tailored support for students challenging. There is a dependence on residential weekends for engineering programmes which require team-working as a national standard for UK professional engineering competence (UK-SPEC). The needs of students with varying mathematical skills have to be met and the problem is acute for students at the Open University where students have diverse educational backgrounds.

Research limitations/implications:
The present work has focused on provisions mainly at undergraduate engineering degree level and so suffers from only considering challenges faced by the system for these groups of learners, who are largely part-time students. It would be useful to also understand the case for postgraduate who are involved in studying for higher degrees (masters and PhD) as well as for other disciplines.

Practical Implications:
Through the provision of an introduction to the use of collaborative online tools at the beginning of the engineering degree programme of studies, there is the potential to foster a greater feeling of community amongst the distance learning students, reduce isolation often associated with distance learning and contribute to achievement of learning outcomes resulting from team work.

**Originality:**
The treatment given to these challenges and the way they have been articulated and presented is unique. In the case of mathematics for engineers, a body of online diagnostics and support materials have been made available that can serve to further develop research within specific areas of engineering.

**Keywords:**
open access, distance learning, engineering, design, mathematics.

**Paper Type:**
Research

1. **Introduction**

The Open University (OU), based in Milton Keynes with thirteen national and regional centres across England, Scotland, Wales and Northern Ireland, is the largest university in the UK with over a quarter of a million registered students (Open University, 2012). The average age of an OU student is thirty two and most study part-time. This total includes approximately four thousand students currently studying towards an undergraduate Bachelor of Engineering (BEng (Hons)) or Engineering Foundation Degree (Eng FD): we will focus here on the BEng (Hons). The majority of our engineering students are in full-time engineering related employment.

The OU has an open access policy and, with very few exceptions, there are no formal academic entry requirements. Some students on the engineering programme will join us with no previous educational qualifications (PEQs), though often with extensive practical vocational experience, whilst others may bring transferred credit from related qualifications, or may already have degrees in other subjects. The university as a whole has a relatively high proportion (~5%) of students with disabilities or additional requirements; this proportion is lower in engineering related subjects and tends to be more focused on specific learning difficulties such as dyslexia.

OU modules are delivered by supported distance learning. Most engineering modules are still centred on printed texts, but these are increasingly being supplemented or replaced by a growing range of online resources. Learning and assessment resources are produced centrally, whilst day to day academic support is provided by a UK-wide network of part time tutors, typically through a mixture of non-compulsory face to face tutorials, online synchronous tutorials and ongoing support via telephone, email and module forums. Students can and do study in a wide range of situations and locations, although internet access is becoming essential for successful study.
1.1. Changes for 2012

The general context outlined above results in a particularly diverse student body, and this poses many challenges for the engineering programme. The following sections of this paper will focus on three particular areas: the need to ensure that new students are adequately prepared for study at university level; the challenge of facilitating and assessing group work effectively within a distance learning environment; the limitations of relying on generic mathematics modules not specifically tailored to engineering. In addition, recent changes to higher education (HE) funding mechanisms in England (UK BIS Department, 2011) are likely to have a profound effect on our student population. Whilst the possible effect on student numbers or student profiles for OU engineering qualifications is hard to predict, administrative changes made necessary by the new funding regime afford us exciting new opportunities to offer more tailored support to our students.

At the time of writing (April 2012) students register for modules one at a time, accumulating HE credit for each module that they successfully complete. Individual modules can generally count towards any one of several different qualifications. When a student has achieved sufficient credit at the required levels of study they can ‘cash in’ their modules for a qualification: for a named degree such as the BEng (Hons) there are specific requirements that must be fulfilled. Thus, although we can identify the students studying a particular module, we cannot be certain which students are aiming to complete a BEng (Hons) until they have completed their studies and cashed in their credit. Furthermore, students can complete modules in any order and, despite our best efforts to offer advice and guidance, there is no guarantee that they will follow a particular recommended route through their degree.

From October 2012 this situation will change. New undergraduate students will be required to register for a qualification right from the start. The flexible BEng (Hons) that we currently offer will be replaced by a new qualification within which there are a small number of tightly specified pathways. For the first time in many years we will have the luxury of knowing not only who our students are, but which modules they will be studying and in which order! We are also well aware that they will be paying (or owing) considerably more for their studies and the consequences of failure will be far more significant, financially, than they are now.

2. Current challenges, new opportunities

In sections 2.1, 2.2 and 2.3 respectively we look in more detail at issues around preparedness for study, online group work and mathematics for engineering.

2.1. Ready for Study?

For new students with few or no formal academic qualifications, or students who are returning to study after a long break, the OU has until recently offered ‘Openings’ modules in several subject areas. These provide some subject specific content but are primarily designed to develop study skills. There has not been an Openings module
specific to engineering, so students have been more likely to embark directly onto our 30 credit introductory level one module in engineering T173: Engineering the future. The module had its first presentation in 2000 and is in the process of being updated. Retention and pass rates on this module have been relatively low compared to other level 1 modules in the faculty, and it performs poorly when considered alongside recently produced modules in other subject areas such as environment or mathematics. However, the financial investment associated with a single module has been relatively small (with many students gaining financial assistance from the University) and it has been straightforward to switch from one subject area to another, so it might be argued that the risk for the student in embarking directly onto a level 1 engineering module, regardless of PEQs, is low.

Table 1: New students gaining credit for T173 for presentations starting between October 2009 and February 2011, according to previous educational qualification

<table>
<thead>
<tr>
<th>Previous educational qualification (PEQ)</th>
<th>Number of students</th>
<th>% of students starting T173 who gain credit for T173</th>
</tr>
</thead>
<tbody>
<tr>
<td>No PEQs</td>
<td>32</td>
<td>28</td>
</tr>
<tr>
<td>&lt; ‘A’ level</td>
<td>492</td>
<td>42</td>
</tr>
<tr>
<td>‘A’ level or equivalent</td>
<td>604</td>
<td>52</td>
</tr>
<tr>
<td>HE qualification</td>
<td>433</td>
<td>58</td>
</tr>
</tbody>
</table>

Table 1 shows how the percentage of new students gaining credit on T173 varies according to PEQ for four presentations of the module starting between October 2009 and February 2011. It is important to note that the figures include students who have switched to a different module or decided to reduce their study intensity, so some of these students will have gained credit on other modules. Clearly, students’ previous educational qualifications have an impact on their likelihood of success and as the OU is committed to open access and widening participation it is essential that we improve students’ chances of success and their progression through the BEng (Hons).

From October 2012, with considerably increased costs and qualification (as opposed to module) based registration, the need to ensure that students are suitably prepared to start their degree becomes far more significant. The new funding regime for England means that students will be eligible for a loan to study a level 0 access module, as long as this is used as a route into a qualification. That is, they will be able to access a loan for 390 credits of study. The Open University will be reconfiguring its access curriculum from autumn 2013 and will include a 30 credit, level 0, module specifically for Science, Technology, Engineering and Mathematics (STEM) students. This module will aim to address the needs of students with a wide range of previous educational experiences and develop their confidence in their ability to study at HE level. It will also need to provide a smooth transition to level 1 and orient the students towards the Open University and its methods of supported open learning. Part of the challenge of producing this module will be to provide sufficient subject ‘tasters’ to enable students to make an informed choice about their subsequent qualification pathway.
2.2. Group work at a distance

A requirement for team-working is included in almost all national standards for the education of engineers, including the UK Standard for Professional Engineering Competence UK-SPEC (EC-UK, 2010). This is a particular challenge when students are studying part-time through distance learning. At present the OU BEng relies heavily on residential weeks held at host universities both for developing practical skills and for providing opportunities for group work. As online tools for collaborative working become more widely available and our understanding of how to use them effectively develops, new possibilities are emerging. One interesting development within the OU has been the production of a highly successful Team Engineering module, which forms a compulsory part of the integrated Master’s degree in Engineering (MEng) and other postgraduate qualifications. Team engineering uses a combination of two residential weekends at the beginning and end of the module, with online collaboration via wikis and video-conferencing in between, to support groups of four to seven students as they work together on an engineering project over a 32 week period (Endean et al, 2008). The creation of teams at the initial residential weekend has proved effective in building good working relationships and the module has not suffered the levels of student resistance to group working reported elsewhere (Zhuge and Mills, 2010). The potential to record the online elements provides a clearly visible record of each student’s participation that can be used in combination with appropriate assessment tasks to judge individual contributions.

Another initiative that facilitates collaborative working for students and has the potential to develop peer assessment is Open Design Studio (ODS). This was developed by the OU as part of U101, Design thinking – a 60 credit, introductory level 1 module. ODS enables students to share images of their design work and allows others to comment on their work (Lloyd, 2011). Figure 1 shows an example of a student’s work on their home page.

Building on experience from U101 and other modules we are planning to introduce an element of online group working into the new version of our introductory engineering module, centred on the Open Design Studio. Figure 2 shows a rough outline of how the online activity will be developed through the module, gradually introducing tools and building skills within structured activities linked to the subject content of each block. Each element of the activity will feed into the assessment for that block, providing an added incentive for students to take part. By providing a gentle early introduction to the use of collaborative online tools at the start of the BEng we hope to foster a greater feeling of community amongst our students and reduce the isolation of distance learning, as well as contributing to the achievement of learning outcomes related to team work.
Figure 1: A student homepage in Open Design Studio

Figure 2. Outline of planned online activity
### 2.3. Maths for engineers

The increasingly wide range of mathematical preparedness amongst entrants to engineering degrees, and the difficulties of dealing with their different needs, has been recognised as a problem for many years (Mustoe, 2002). Several different approaches to addressing this have been trialled, with varying degrees of success (Perkin and Bamforth, 2011). The problem of poor mathematical skills on entry is particularly acute in the OU, where students come from a wide range of educational backgrounds and may not have studied mathematics formally for some time. Many of the traditional approaches, such as additional lectures or drop-in problem classes can be hard to replicate in a distance learning environment. We provide a variety of online diagnostic and support material, which typically includes practise questions with multiple variants that can be marked instantly: an example can be seen at [http://mathshelp.open.ac.uk/](http://mathshelp.open.ac.uk/).

The range of question types available and the sophistication of the feedback that can be provided is a key focus of institutional research within the OU and continues to develop. See for example (Ross, Jordan and Butcher, 2006; Butcher and Jordan, 2011).

In addition to the maths embedded in the core engineering modules, OU engineering students are currently required to study at least one specified 30-credit maths module. From October 2012 the requirement will increase to 60 credits of specified maths modules. These are generic mathematics modules designed primarily to suit the requirements of the mathematics programme, but which are also utilised by other subject areas, particularly (but not exclusively) engineering and science.

Under the module-based registration system it has not been possible to distinguish between students studying maths modules with different qualification aims. All students are presented with the same material, delivered in the same way by a tutor assigned in most cases according to geographical location. They take the same assessments and are judged by the same standards. However, students have had some choice over the level at which they start their mathematics studies; those struggling with the ‘standard’ maths offering have been able to switch to a ‘gentle start’ option, progressing to the more demanding standard module at a later stage.

Under the new qualifications framework it will become possible to easily distinguish between cohorts of students on particular study pathways, presenting new opportunities to tailor maths support more closely to the needs of particular groups of students. However, the possibility of switching to a ‘gentle start’ has effectively been removed for BEng (Hons) students since the new tightly defined qualification pathways do not include this option. There is no resource available for developing bespoke maths modules for our engineering students, but various interventions are under consideration to improve the advice and support that we can offer our students. It is important to remember that most of our students are combining study with work, family and other commitments and often have little or no potential for increasing the amount of time available for study: merely giving them extra work to do is unlikely to succeed. Table 2 lists current provision together with possible interventions that are under consideration at different points in the study calendar. We intend to trial some or all of
these over the next few years in order to judge the most effective way to improve the support we offer to our students.

Table 2. Maths support options for OU engineering students

<table>
<thead>
<tr>
<th>Point of intervention</th>
<th>Current provision</th>
<th>Possible intervention</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-registration</td>
<td>Online diagnostic quizzes are available for students to test whether they have the required maths skills, but are not compulsory.</td>
<td>Students may be required to complete a maths diagnostic quiz before registering for an engineering qualification and directed towards preparatory material where necessary. This could be linked to registration.</td>
</tr>
<tr>
<td>Allocation to tutor groups</td>
<td>Tutor groups contain a mixture of students with different qualification aims.</td>
<td>Engineering students could be grouped together and assigned to tutors with specific background/interests in engineering.</td>
</tr>
<tr>
<td>Student struggling early in module</td>
<td>Students may be advised to begin with a module at a lower level and try again later.</td>
<td>Students could be advised to temporarily reduce their study intensity, and provided with support to complete preparatory material.</td>
</tr>
<tr>
<td>During the maths module</td>
<td>Routine support from tutor, feedback from written assessments and online quizzes, optional tutorials, limited provision of one to one support sessions to address specific needs.</td>
<td>Greater emphasis on engineering relevance of module material and prioritization of certain aspects over others. Online support sessions to cover particular areas of difficulty.</td>
</tr>
<tr>
<td>At the end of the module</td>
<td>No distinction between students with different qualification aims.</td>
<td>Thresholds for progression, or weighting of assessment components, could differ according to qualification aim.</td>
</tr>
</tbody>
</table>

3. Conclusion

In this paper we have summarized a few of the challenges currently facing the Open University in delivering undergraduate engineering qualifications through open and distance learning, and some of the steps that are being taken to address them. These issues have been brought into new focus by recent changes in the funding of HE in England, which have necessitated major changes in the way the OU organizes its provision. The changes offer some potential benefits, but by reducing the flexibility available to students they increase the responsibility of the engineering programme to ensure that they make the right initial choices and are well supported throughout their studies. Open access is a fundamental principle of the Open University and we are committed to retaining it along with a commitment to widening participation. The production of a new access module specifically designed for students intending to study STEM subjects can only benefit students who have low previous educational qualifications or who have been out of the education system for a long time.

The OU specializes in distance learning and has built up an excellent reputation for the quality of our provision, but effectively facilitating and assessing group work in engineering is a particular challenge. A rewrite of our introductory level 1 module provides an opportunity to imbed recently developed web resources that enable
encourage students to collaborate together in a supervised and structured online environment. Finally, the new ability to distinguish between students studying generic mathematics modules towards different qualification aims provides us with an opportunity to provide more tailored mathematics support to students within the engineering programme. We would welcome opportunities to collaborate with other interested parties on all these issues.

4. Acknowledgements
We are grateful to OU student Andy Hart for permission to use the material in figure 1.

References


