Responding to the changing HE environment: developing a sustainable engineering curriculum for part-time distance learning students.

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Abstract

This paper outlines the changes made to the engineering curriculum at The Open University in response to funding changes implemented in 2012 which enabled part-time, distance learners in England to access student loans. The paper also describes changes to overall qualification design including the way in which mathematics is taught to engineering students, moving away from 'service teaching' towards incorporating mathematics teaching into the core engineering modules. Mathematics is now taught in the context of engineering with less emphasis on derivations and mathematical proofs and with greater emphasis on understanding basic concepts and being able to create useful models. Personal and professional development planning has also been embedded into engineering teaching for improved context and relevance.

1. Introduction

The Open University (OU), based in Milton Keynes with six national and regional centres across England, Scotland, Wales and Northern Ireland, is one of the largest universities in the UK with over 170,000 registered students. This total includes approximately 4500 students currently studying towards an undergraduate Bachelor of Engineering (BEng (Hons)), Bachelor of Engineering Top-up (BEng (Hons)), Master of Engineering (MEng), or Engineering Foundation Degree (Eng FD).

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 join with no previous educational qualifications (PEQs), though often with extensive practical vocational experience, whilst others may bring transferred credit from HNC or HND qualifications. The majority of our engineering students are in full-time engineering-related employment.

As a result of higher education funding changes for England in 2012, the OU changed its student registrations from module-based to qualification-based to enable access to loans for part-time study. This change resulted in more prescriptive and structured routes through the engineering degrees as well as identification of students registered for particular

qualifications. This enabled the performance of students on individual modules making up the qualifications to be interrogated more easily at a qualification level and problems identified. The changes were reported by Organ and Morris [1] in 2012.

We identified that engineering students were performing poorly on two, 30 credit, compulsory mathematics modules and consequently failing to complete their first year (equivalent full-time) of study successfully. Anecdotal evidence and feedback from students suggested that engineering students would benefit from greater connections between mathematics principles and relevant engineering topics and techniques.

Personal development planning (PDP) and professional skills development towards employability have featured in the OU engineering qualifications for a number of years. However, distinct PDP modules have not proved as popular with students as core engineering modules. The importance of these skills to a student studying towards an engineering qualification were not as widely recognised by students as intended, predominantly due to these modules being studied in isolation.

Following an evidence-based approach we proposed a restructuring of the engineering qualifications to incorporate mathematics teaching in an engineering context alongside key skills and PDP. The new structures incorporate revised study patterns allowing students to pace their studies more effectively alongside their work and family commitments. Teaching is delivered primarily as print and online media distance learning with some face-to-face tutorials and laboratory based residential schools.

Mathematics skills, personal and professional development planning, practical laboratory based residential schools, and wider skills are all integrated into broader modules that provide context and relevance to students while they are studying engineering topics. We have also taken an integrated approach to assessment, developing an assessment strategy for each stage of the qualification rather than on a module-by-module basis.

2. Curriculum changes

2.1 Mathematics in an Engineering context

The wide range of student abilities in mathematics skills and preparedness on entry to engineering degrees has been recognised as problematic for a long time [2]. The problem is exacerbated at The Open University as students come from a wide range of educational backgrounds and may not have studied mathematics formally for many years. Many students also exhibit low confidence in dealing with mathematics. Approaches to help students on entry to conventional HEIs [3], such as additional lectures or drop-in support sessions, are impractical in a distance-learning setting. We know that the majority of our engineering students are in full-time employment and frequently combine study with work and family commitments and have finite time for study. Strategies that give students additional workload to strengthen their mathematical skills are unlikely to succeed in the context of the OU.

From October 2012 to February 2016 our engineering students were required to study 2 x 30 credits of mathematics at level 4 from a choice of 3 x 30 credit modules. The two

modules included a compulsory 30 credit module in *Essential Mathematics*. The second mathematics module choice would either further support open entry students requiring more introductory practice in mathematics or alternatively provide a more challenging mathematics module for those more mathematically confident students intending to study further engineering mathematics at a higher level. The compulsory *Essential* Mathematics module was designed primarily to satisfy the requirements of the mathematics teaching programme and students on mathematics qualifications. The module was available to study either from October to June or from February to September each year. The proportion of BEng (Hons) students gaining credit on *Essential Mathematics* in the period from October 2012 to February 2016 varied from 34 to 51 percent.

Although there was an upward trend in the percentage of BEng (Hons) students gaining credit over the period it was, nevertheless, at an unacceptably low level and having a detrimental impact on progression from level 4, as students were required to either re-sit the end of module examination or retake the module at the next opportunity.

From October 2016 students no longer study mathematics modules in isolation. We have integrated mathematics teaching into the core engineering modules, ensuring that it is taught in context.

Much of the base content has been adapted from the existing mathematics modules. The emphasis has been on understanding basic concepts, creating useful models and recognising reasonable solutions to engineering problems. We also encourage students to experiment and to use dimensional analysis to aid their understanding and to check their results. We have placed less emphasis on deriving or proving mathematical relationships or using specific methods at this early stage of the qualifications. We hope that our approach will discourage students from learning mathematics by rote and consequently being unable to apply it to unfamiliar situations.

2.2 Personal development planning (PDP) and skills development

We have incorporated PDP into our engineering qualifications for many years to ensure our graduates are well prepared and to enhance their employability. Our qualifications align with the requirements of the UK Standard for Professional Engineering Competence (UK-SPEC) [4]. Prior to 2012, students were required to study 2 x 15 credit specialist PDP modules at level 4 and level 6. Student loan funding changes in England necessitated combining learning content into larger credit modules. This provided the opportunity for us to integrate PDP into other engineering modules. We have done this by integrating PDP with technical content, engineering professions case studies and compulsory practical engineering residential schools to produce 2 x 30 credit modules – one at level 4 and one at level 5.

It cannot be assumed that on entry to The Open University students automatically have the skills required for successful study at degree level as approximately one-third enter the university with no ‘A’ level (or equivalent) qualifications. Even those with conventional university entry qualifications frequently lack the skills required for distance-learning or have not studied for several years.

As with mathematics, we have taken the approach of integrating PDP and study skills into core engineering modules, enabling key skills such as communication, presentation skills and report writing to be studied alongside relevant engineering concepts. Students maintain a log of their learning activities which forms the basis of a portfolio of evidence which can be used if they subsequently apply for chartered status with a professional engineering institution after graduation.

2.3 Study patterns

Prior to October 2012 engineering students could study up to 120 credits in an academic year, although the majority chose to limit their study to 60 credits a year. However, the times at which different modules were available meant that approximately half of new entrants to the engineering programme were studying 2 x 30 credits concurrently (from October to June) resulting in high intensity study, and then having a break until the following October. This study pattern meant that students often had conflicting assessment cut-off dates and were frequently struggling to get their assessments submitted on time.

We have amended study patterns so that students study the first 2 x 30 credit modules of their engineering qualification in succession over a 12 month period, with the first module, (*Engineering: origins, methods, context*) being studied from October to March and the second (*Engineering: frameworks, analysis, production*) studied from April to September. Our aim is to ensure that students do not have conflicting assessment dates, are able to concentrate on one module at a time at this early stage of study, and are able to utilise knowledge and skills acquired in the first module to successfully study the second module. Sequenced skills development plays an important role alongside knowledge attainment as students progress through the modules.

A schematic of the modules studied at level 4 for the BEng (Hons) and MEng is given in Figure 1.

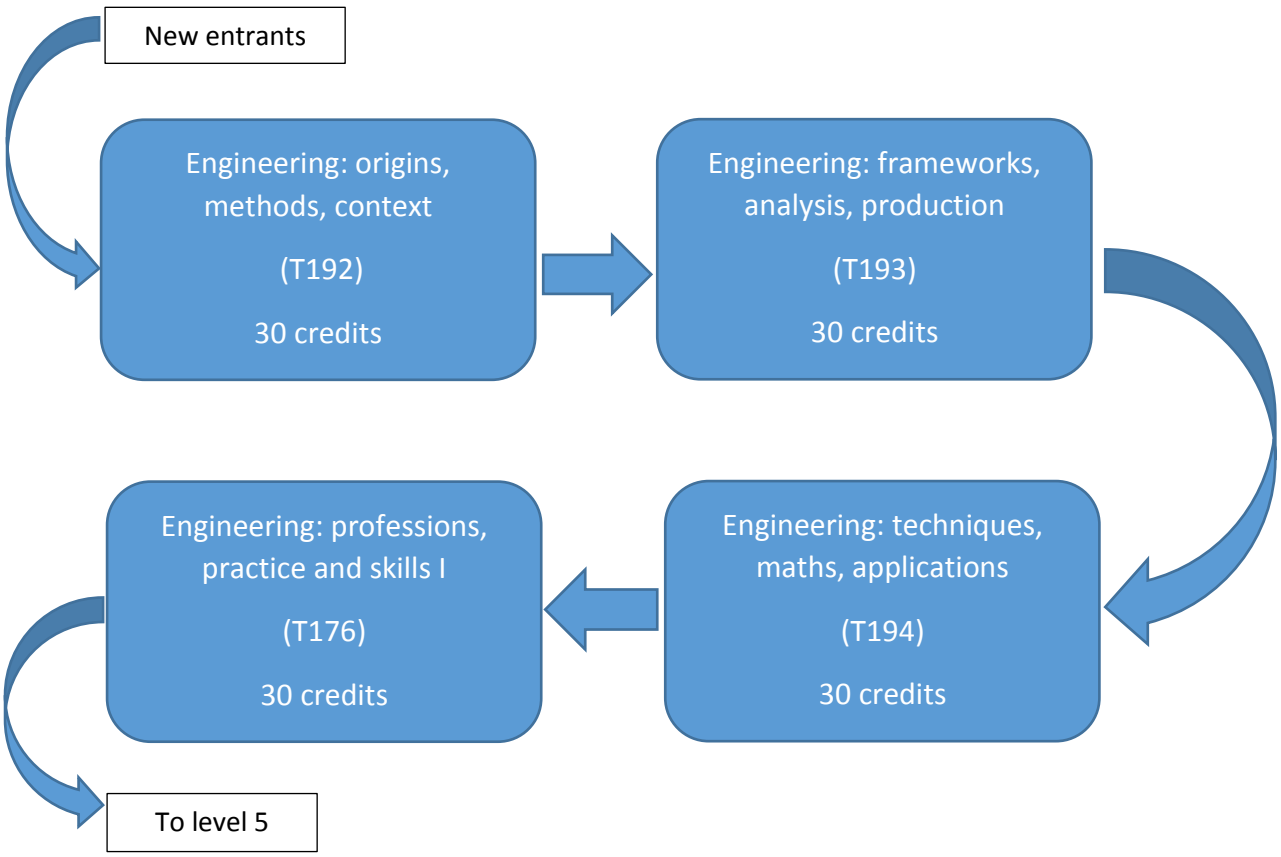

Figure 1: Schematic of study order for new entrants to OU engineering qualifications from October 2016

3. Assessment

We have taken a qualification-based approach to assessment, ensuring that assessment tasks build in difficulty as students progress through each module and build in type as they progress through the qualification stage. Students are required to complete formative activities designed to feed into summative assessment at regular intervals and if they complete these activities at the appropriate time assignments should be straight-forward and not the last minute rush often experienced by part-time learners. Pacing of assessment activities in this way also benefits reflective skills development as adequate time remains close to an assessment deadline for students to review their work, complete self-assessment reflective activity, and finalise their assessment submission. Student self-assessment of learning outcomes attainment is also built in to assessments, ensuring good student engagement.

Students are continuously assessed through tutor-marked assignments (TMAs) and interactive computer-marked assignments (iCMAs) combined with end-of-module assignments and examinations where appropriate.

Practice quizzes are incorporated into most weeks' study for the duration of the first three modules and the time taken to do them is accounted for in the overall study time. These quizzes enable students to have multiple attempts at particular mathematical problems, with feedback given for incorrect answers.

More formal mathematical assessment at level 4 takes the form of iCMAs developed at the OU and outlined by Jordan [5]. Students are allowed 3 attempts at each question, with feedback for incorrect attempts suggesting where the student has made mistakes and referring them to appropriate module material as necessary.

iCMAs and practise quizzes are combined with tutor-marked assignments to ensure that all learning outcomes are assessed appropriately.

4. Initial results

At the time of writing, the first cohort of students that entered the University in October 2016 has completed the first 30 credit module, *Engineering: origins, methods, context.* Early indications are that 754 of the 1017 new entrants (74%) have completed the first module, and almost all of those are progressing to study the second module, *Engineering: frameworks, analysis, production*, starting in April 2017. Retention rates of this order are very encouraging given that this is the first entry module of an open-access qualification where students are often encountering distance learning for the first time. This retention rate is significantly higher than that achieved by the previous entry module prior to October 2016, which varied from 65-68%. We will not be able to make meaningful comparisons with previous cohorts until all study at level 4 has been completed, but we are confident that greater numbers of students will progress successfully to level 5 and beyond.

5. Future plans

The ethos and methodology applied to level 4 of the engineering qualifications will be continued as higher levels of the curriculum are redeveloped. Based on evidence to date, and our experience so far through the redesign of the engineering curriculum, we will continue to work towards qualifications that are more integrated in nature. Engineering context is key to a part-time distance learner, particularly when they are already employed in a sector relating to their chosen academic subject. However, we have taken care when choosing examples, case studies and images not to make assumptions about students' prior experience and to make the teaching material relevant to a diverse student group. The integration of mathematics teaching with core engineering content is proving more popular with students and their tutors, particularly at the early stages of the qualifications. We will also continue the integration of personal and professional development planning with context driven technical engineering content towards enhancing student academic success and employability skills.

6. Conclusions

Although it is too early to make any firm conclusions about the success of the reconfiguration of the undergraduate engineering curriculum at The Open University we are encouraged by

early indicators and the increased student retention rate on the first module of the revised qualifications.

References

1. S.J. Organ and C. Morris “Open and Distance learning for Engineering; Opportunities and Challenges” in *International Conference on Engineering Education*, Turku, Finland, 2012, pp. 1089-1096
2. L. Mustoe, “Mathematics in Engineering Education”, *European Journal of Engineering Education*, vol. 27, No. 3, pp. 237-240, 2002.
3. G. Perkin and S. Bamforth “A Variety of Approaches to the Provision of Mathematics Help for First-year Engineering Undergraduates*”, International Journal of Electrical Engineering Education*, vol. 48, No. 1, pp. 79-91, 2011.
4. Engineering Council, “UK Standard for Professional Engineering Competence (UK-SPEC)”, Third Edition, 2014.
5. S. Jordan “E-assessment for learning? Exploring the potential of computer-marked assessment and computer-generated feedback, from short-answer questions to assessment analytics.” PhD dissertation, The Open University, Milton Keynes, 2014