Changing direction: understanding and promoting mature female entry to undergraduate engineering programmes.

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INTRODUCTION
There have been many initiatives in the UK over the past 30 years aimed at increasing the number of girls studying STEM subjects, which have resulted in roughly equal numbers of girls and boys studying these subjects up to age 16. However, beyond this age only 20% of ‘A’ level entrants for physics are girls [1], and they report concern that studying physics limits their career options [2]. As a result, only 15% of engineering undergraduates in the UK are female. Other initiatives have focussed on encouraging women already qualified in engineering to return to the profession after a career break [3]. Despite these initiatives the proportion of women working in engineering professions in the UK remains low at approximately 11% [4]. The Open University (OU) is an open access, distance-learning institution which offers full and part-time degree level study in engineering, potentially providing an alternative route into the profession for mature women who are new to the discipline.

The aim of our research is to understand the motivations of mature women studying engineering qualifications at the OU. By developing an understanding of the motivations and career aspirations of these students we hope to increase the number of mature women studying and entering the engineering profession. An initial literature review of existing strategies and interventions from UK universities encouraging mature women into engineering revealed that no substantive work exists in this area.
This paper reports the initial results from a detailed online survey for all actively studying female engineering students at the OU, together with an equivalent number of male students, to gather information on the similarities and differences between female and male students’ motivation for study, academic interests and career aspirations. The results indicate that mature female students are more likely to be motivated by a desire to change their careers, whereas a higher proportion of male students are already in engineering employment and are motivated by career enhancement. Interesting differences have also been identified in the aspirations, attitudes and interests of the female students compared to the men.

The implications of these results and plans for further studies are discussed.

1 ENGINEERING AT THE OPEN UNIVERSITY

The OU offers a range of undergraduate engineering qualifications at different levels, designed to support different professional recognition intentions: Foundation degree/Diploma of Higher Education (240 CATS credits with a vocational focus), BEng (Hons) (360 CATS credits, partial CEng accredited), Top-up BEng(Hons) (120 CATS credit top-up to a vocational qualification, IEng accredited) and MEng (480 CATS credits, CEng accredited). These qualifications are all in general engineering and cover a broad curriculum, with some limited scope for specialisation. For example, for the BEng(Hons), specialist options are available in engineering design, electronics, energy and sustainability, environmental technologies and mathematical methods.

With the exception of the Top-up BEng, there are no formal entry requirements to the qualifications. Approximately one-third of students begin OU study with no formal qualifications, while others already have degrees in other subjects. At the start of 2018 there were 5742 students actively studying for an OU engineering qualification, of whom 563 (9.8%) were female. This is less than the sector average of 15% female students entering engineering degrees in the UK [5]. The most recent cohort of students, starting their study in 2017/18, were mostly in the 30-39 age group, with 73% working either full or part time, often in the engineering sector.

2 STUDENT SURVEYS

In order to find out more about the motivations and career aspirations of our female engineering students and, for comparison, their male peers, two surveys were sent out. Ethical approval was obtained and the project was approved and supported by the University Student Research Project Panel. We also sought guidance from the OU’s marketing experts about the suitability and ordering of the questions. The first survey took place in November 2017 and was a small pilot survey sent to 65 women registered for an engineering qualification and studying their first module (T192 Engineering: origins, methods, context, 30 CATS credits). The same survey was sent to 125 male students to allow comparisons to be made. Responses were received from 18 women and 10 men. The surveys included questions exploring the reasons why students had chosen to study engineering with the OU, their personal interests and motivations, previous educational and career experiences, their feelings about their study experience and the attitudes of others.

Based on the results from the pilot survey some small changes were made and a second survey (described here as the main survey) was sent to all other actively studying female engineering students and a slightly larger number of randomly selected male engineering
students. Responses were received from 58 (out of 311) women and 51 (out of 489) men. OU policy limits the number of surveys an individual student can be asked to complete in an academic year, therefore the number of women surveyed is less than the number actively studying. For analysis the results from the two surveys have been combined, except in the few cases where a change to the survey prevented this.

3 RESULTS AND DISCUSSION

3.1 Overview

Institutional data including student age, geographical location, socio-economic status, ethnicity, previous educational qualification and disability enabled us to compare the overall profile of our sample with that of all OU engineering students. No significant differences were found, confirming that, with the exception of gender, our sample is broadly representative of the overall OU engineering student population.

Data analysis from the questionnaire revealed some similarities between the responses from men and women, but also several significant differences. A two-tailed chi-squared test was used to determine whether significant differences existed between male and female responses, with the null hypothesis being that there was no difference between women and men. The main differences are reported below and have been categorised into four areas: work, aspirations, attitudes and interests. Results have been rounded to the nearest whole percentage and options with very low response rates have generally been omitted, so totals may not add up to 100%.

3.2 Work

Table 1 shows that the majority of the students are working, although more men work full time than women. However, there are marked differences in their working situation: more than half the men are already working in engineering, while women are more likely to aspire to work in engineering in the future.

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<th>Table 1. Current work situation</th>
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The responses to the question ‘What was your main reason for choosing to study engineering’ confirm this finding, as shown in Fig. 1. The vast majority of students of both genders were studying for career related reasons, but for men the main motivation was to progress in their current career and this was a very significant difference when compared to the women (p = 0.005). For women there was a balance between studying to progress their current career, to change career, or to enter the engineering profession. Many of the women are already well qualified: it is notable that 46% of the female students surveyed already have a degree in another subject, compared to 16% of men, resulting in another very significant difference (p = 0.0071).

![Fig. 1. Main reason for choosing to study engineering](image)

Although the Open University collects employment details under eight broad categories, such as ‘technical and craft occupations’ and ‘modern professional occupations’ the main survey revealed an extremely varied spectrum of current occupations for both genders. There were 49 different occupations cited by female respondents, ranging from low-waged, low-skilled employment such as ‘cleaner’ to highly-paid, high-skilled employment, such as ‘lecturer’ and ‘solicitor’. Similarly, the men in the main survey cited 45 different occupations, ranging from ‘shop assistant’ to ‘quantity surveyor’. One student stated that he was a ‘professional yachtsman’. The difference in work situation was reflected elsewhere: for example, 26% of men were being sponsored by their employer, with 68% paying the fees themselves or taking out a student loan. In contrast, only 7% of women were sponsored, with 82% paying the fees themselves or taking out a student loan.

### 3.3 Aspirations

Fig. 2 shows a comparison of the qualification intentions of male and female students. A greater proportion of women are aiming for the higher level qualifications, however this difference was not found to be statistically significant. Women are much less likely to be following a vocational pathway, which correlates with the fact that far fewer of them are already working in engineering and the difference was found to be statistically significant (p = 0.0243).
Fig. 2. Qualification intention

The higher aspirations of the female students are also reflected in their professional registration intentions, as shown in Fig. 3.

a) b)

Fig. 3. Professional registration intention a) women b) men

3.4 Attitudes

The questionnaire asked students whether they had been encouraged to study engineering by different groups of people: the results are shown in Fig. 4. Men received greater encouragement in all categories, although the differences were not large and were not statistically significant. It is interesting to note that the percentage of women encouraged to study engineering by their employer (24%) is higher than the percentage of women currently working in the engineering sector (19%), so this could be regarded as a very positive result.

Fig. 4. Source of encouragement to study engineering
In the main survey only, students were asked a range of questions concerning how they felt about their studies and were asked to respond on a 5-point scale with options ranging from ‘strongly disagree’ to ‘strongly agree’. A selection of the results are shown in Fig. 5. The main areas where there was a noticeable difference were around confidence to succeed, awareness of being in a minority and level of previous knowledge. Other questions were about ability to keep up with other people and working with others where the responses were very similar for both genders. Unsurprisingly, the statistical significance of the number of women who were aware of being in a minority was extremely high (p < 0.0001).

Fig. 5 shows some interesting differences in confidence levels: although a higher proportion of the women strongly agreed that they were confident to succeed on their qualification compared to the men (48% women, 35% men) the overall confidence levels (strongly agree + agree) are higher for men (84% women, 94% men). A similar but less pronounced effect was seen for confidence in mathematics. None of these observations were statistically significant.

![Bar chart showing feelings about study](chart)

**Fig. 5.** Feelings about study

Women were far more likely to be aware of being in a minority (64% strongly agree, or agree), despite the fact that they are studying largely independently and rarely have opportunities to meet fellow students face to face. A smaller number of men (18% overall) were also aware of being in a minority, so this is an area that warrants more detailed investigation to identify whether ethnicity, disability, sexuality or some other reason are cited by men as placing them in a minority. There is also a marked difference in the response to ‘I believe I have a similar level of previous knowledge to others on the qualification’ (22% of women strongly agree or agree, compared to 47% men), which is perhaps linked to the fact that more men are currently working in engineering. This finding was statistically significant with p = 0.0089.

### 3.5 Interests

Students were presented with a list of current engineering challenges, influenced by those identified in the National Academy of Engineering Grand Challenges for Engineering report [6] and asked which were of particular interest to them. They were also given the opportunity to state other areas of engineering that particularly interested them. The results are presented
in Fig. 6 in the form of ‘wordles’ [7] where the size of each word represents the number of times it occurred.

Fig. 6. Engineering topics of particular interest to a) women and b) men.

Fig. 6 reveals some common interests but also highlights some different priorities between the two groups. Sustainability and environmental engineering feature highly for both sets of students and, along with energy, are reasonably well catered for in the OU engineering curriculum. However, civil engineering, which emerged top of the list for women but was a much lower priority for men, is not offered as a specialism.

4 SUMMARY AND ACKNOWLEDGMENTS

The information obtained from both the pilot and main surveys has revealed some significant differences between the motivations and aspirations of both genders and their current employment situation. Although our female students tend to enter the University with higher previous educational qualifications than the men, they may be disadvantaged in their study by not being in engineering-related employment. This has implications for academic staff when constructing the curriculum as they have previously assumed that the majority of our students have an engineering-related background, will understand commonly used engineering terms and possess many of the technical and craft skills required for successful study.

The next phase of the study will be to conduct one-to-one in-depth interviews with students to enable us to gain a deeper understanding of their motivations and aspirations. 47 survey respondents (29 women and 18 men) have indicated a willingness to take part in these interviews which we hope to complete during August - September 2018. We also wish to understand the barriers to study that many students in a distance-learning environment have to overcome and whether these barriers are related to gender.

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REFERENCES


