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Exploring The Variation In Gender Balance On Undergraduate Engineering Courses In UK Universities

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ABSTRACT

The underrepresentation of women in engineering remains a persistent issue despite efforts to attract more female students. The percentage of UK engineering undergraduates who are female is published annually, however no institutional breakdown is given. This scoping study aims to inform the direction of future research by investigating the nature and possible causes of the distribution of female engineering undergraduates across the UK HE-sector. Student data gathered from UK universities by the Higher Education Statistics Agency (HESA) for 2019/20 is explored using Tableau. Overall, 16% of UK engineering undergraduates are female but this varies from 5% to 36% for individual universities, with more prestigious institutions generally having a higher percentage. The findings suggest some association between gender balance and the level of qualifications prior to university: in general, the higher the academic achievement on entry to a university the better the gender balance at that institution while the percentage of women appears to be independent of the number of engineering undergraduates at a university. The HESA data also confirm that certain disciplines attract more women and consequently the subject areas offered by a university can influence its gender balance in undergraduate engineering. The literature offers several possible explanations for these findings, but further study is needed to investigate the differences in female representation at a more granular level, acknowledging the agency and individuality of both the universities and the students.

1 INTRODUCTION

1.1 Underrepresentation of women in engineering

Underrepresentation of women in engineering remains a persistent issue in the UK despite substantial efforts to attract more female students. Around 18% of students studying for a degree in engineering and technology are female compared to 57% for all degree subjects (Engineering UK 2020). The percentage of UK engineering undergraduates who are female is published annually, however no breakdown is given by Higher Education institution (HEI). A review of literature shows substantial research into *why* women may or may not choose to study STEM subjects or, more specifically, engineering, while further research is recommended into *where* they are studying (Ro, Fernandez and Alcott 2021). A more even distribution of female engineering undergraduates across the HE-sector will not increase the overall numbers, however a scoping study to understand the current distribution can inform future research e.g. do some universities actively attract women who might not otherwise have considered engineering while some HEIs are so discouraging that the potential female students choose non-engineering options?

There is a link between increased socio-economic status (SES) of the family and the likelihood of enrolment at more prestigious universities (Carpentier 2021), but the literature is inconsistent regarding gender balance in STEM and the status of a UK university. Codiroli McMaster (2017) suggests the likelihood of young women choosing STEM (Science, Technology, Engineering and Mathematics) over other high-return subjects increases with increased family SES whereas Ro, Fernandez and Alcott (2021) found a lower level of women's participation in STEM subjects at prestigious universities.

The research questions guiding this study are:

RQ1: How are female engineering undergraduates distributed across UK universities, by university type and discipline?

RQ2: Are there characteristics shared by universities with equivalent percentages of female engineering undergraduates?

1.2 Undergraduate engineering at UK universities

In the UK, students apply for undergraduate courses through a central university and college admissions service (UCAS) by selecting up to five combinations of university and programme of study. A university specifies its academic entry requirements for each of its programmes as either A-level (or equivalent) subjects and grades, or a more generalised 'UCAS tariff', consequently students' application options are limited by their academic qualifications. It is worth noting that a student is normally expected to stay at the same institution throughout their degree course and it is also less straightforward to change 'major' than in other HE systems – in fact the concept of a 'major' is less relevant in the UK as engineering is frequently the only subject studied on the programme (ie without humanities or social science modules as in the US). Consequently, an application to study engineering and a university's offer of a place are major commitments on both sides and carry an element of risk, especially if the student has not been exposed to engineering at school.

The UK HE-sector became nominally unitary when a binary divide between universities and polytechnics was abolished in 1992. However, it is widely acknowledged that hierarchies exist, often subdivided into Russell Group (a self-selective elite group), the remaining 'pre-92' HEIs, and those established 'post-92'. These categories are often assumed to align with institutional differentiation by prestige, resource and mission e.g research or teaching focus, academic or vocational priority, and international, national or local outlook (Carpentier 2021). Annual tuition fees for all UK undergraduate engineering courses are the same and are usually covered by a loan through the national student finance scheme (although Scots attending Scottish universities are currently fully funded). However, the cost of living in different locations may influence a student's choice of university.

2 METHODOLOGY

This baseline study analyses data on all UK undergraduates studying engineering in the academic year 2019/20 - the most recent year unaffected by COVID19 - at the 73 HE providers with the largest cohorts which together cover 95% of the undergraduate engineering studied in the UK (excluding the Open University which only offers distance learning) according to submissions to the Higher Education Statistics Agency (HESA). The dataset, which includes 22 Russell Group (RG) universities, 20 non-RG from pre-92 and 31 post-92 establishments, includes student gender and domicile along with the branch of engineering studied, rounded for anonymity and provided as Full Person Equivalent (FPE) (HESA 2023). The visual analytics software Tableau is used to explore this large dataset. It is noted that additional data gathered from university websites was collected in 2022 and this information may have changed since the students applied for their programmes.

The university characteristics explored are: type of HEI, number of students, disciplines offered, and programme access requirements (both academic level and whether physics is required). While these characteristics have all been proposed anecdotally as influencing the gender balance of university engineering programmes, others may also be relevant and give opportunity for further study.

3 RESULTS

3.1 Distribution of female engineering undergraduates by university type

Nationally, the proportion of UK undergraduate students who are female across all engineering disciplines is 16%. The value for individual universities ranges from 5% to 36% with Figure 1 showing a bimodal distribution, suggesting there could be two different categories of universities. Differentiating by RG, pre- and post-92, gives not two but three categories, indicated by the colours in Figure 1. This shows that RG universities have, in general, the best gender balance while the newer universities have the lowest percentage of females on their programmes. The values for pre-92 HEIs that are not RG are more broadly distributed. As RG universities all pre-date 1992, the three categories could be reduced to two by combining RG and Pre-92 as 'old' and post-92 as 'new' which would better fit the bimodal distribution.

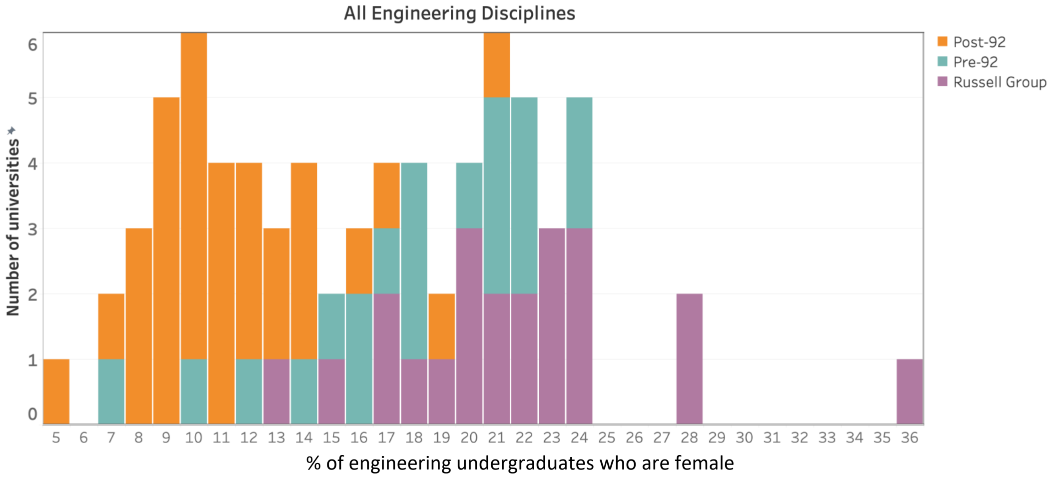

Fig. 1. Distribution of universities by percentage of UK engineering students who are female, indicating university category

The additional characteristics being investigated for RQ2 could be mediating the relationship between the age of the university and the percentage of females on engineering programmes. In addition, as university type is a nominal category, further insight may be gained by exploring some numerical characteristics.

3.2 Engineering disciplines offered

Certain engineering disciplines attract a higher proportion of female students than others (Engineering UK 2020), with the HESA category of bio-, medical-, and biomedical (BMB) engineering having the highest percentage of women nationally. (Prior to 2019, BMB was part of 'general' engineering but, with a change of HESA coding categories, it is now a distinct subset of engineering.)

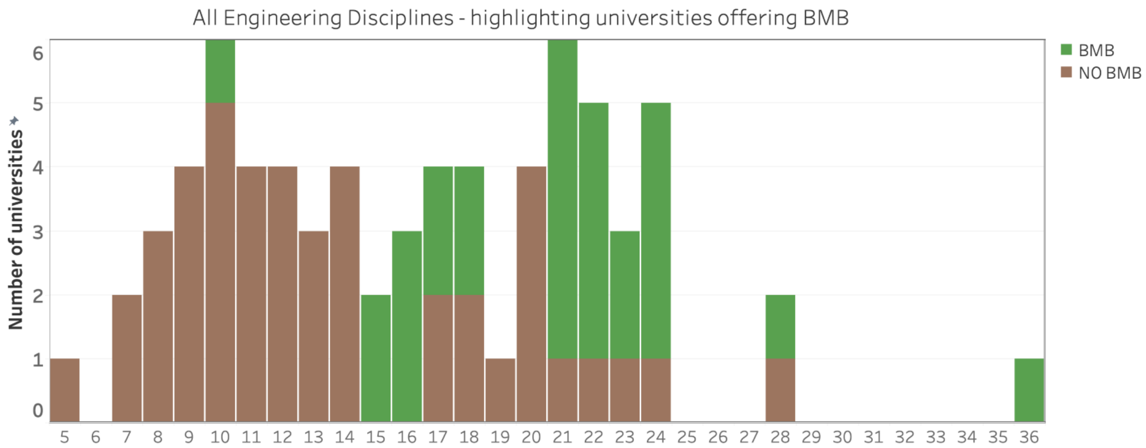

Fig. 2. Distribution of universities by percentage of UK engineering students who are female, highlighting those offering BMB engineering

Figure 2 shows that the universities offering biomedical engineering are likely to have an above average percentage of female students across all engineering disciplines. BMB programmes represent a small proportion of the overall study of engineering but may still provide enough female students to influence the gender balance of an individual university across all engineering disciplines. Offering a BMB programme could also be a mediating factor leading to a higher percentage of females via another mechanism eg a university's offerings being perceived as more cutting-edge.

Analysis of the HESA data shows that the national female representation for the five most populous engineering disciplines is largely repeated at individual university level with the highest female percentages in BMB, followed by chemical, process and energy engineering (CPE), then civil engineering, with electrical and electronic (E&E) and mechanical vying for bottom place. The nature of disciplines offered by a university could influence the overall representation of women on the engineering programmes eg the university with 36% women on its engineering programmes only offers two disciplines, one of which is BMB. It is therefore worth revisiting the university distribution histogram but this time for individual disciplines, once again highlighting the different university types.

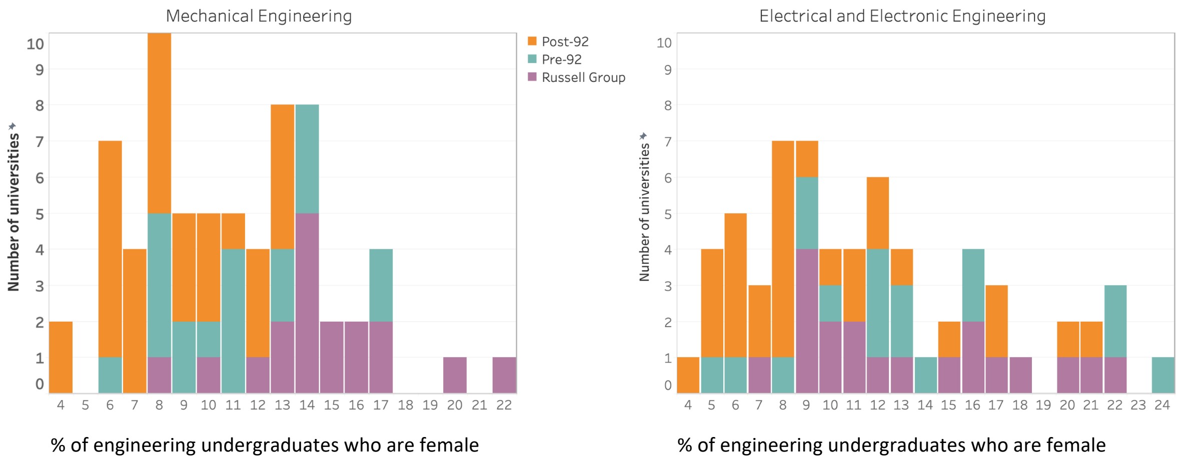

Fig. 3. Distribution of universities by percentage of UK mechanical and E&E engineering students who are female, indicating university category

Of the five disciplines examined, the distribution for mechanical engineering (Fig 3 left) is the closest to the bimodal curve for all disciplines (Fig 1) with a similar representation by RG, pre- and post-92. In contrast, E&E engineering (which, at a national level, competes with mechanical engineering for the lowest representation of women) is the *least* like Figure 1 with a much less distinct distribution of university categories. This suggests that a more nuanced approach is needed to understand why the result for E&E engineering looks so different.

3.3 Number of engineering undergraduates

Another anecdotal suggestion is that the representation of women on engineering programmes increases with the size of the engineering provision, so a larger cohort would be expected to have a higher percentage of female students. Figure 4, where each circle represents an individual university, shows that the 73 universities being investigated have between 495 and 4415 undergraduates (FPE, subject to rounding) registered as studying engineering in 2019/20. As the number of students increases, the distinctions between the 'old' and 'new' universities become more pronounced, with the 'old' universities having the higher percentage of women. Below 1000 students, the picture is much less clear with some small cohorts at 'new' universities getting substantially better female representation than small cohorts at 'old' HEIs. This suggests that whatever the mediating factor is that is leading to the differentiation between 'old' and 'new' universities, there is an additional interfering influence that negates this for smaller cohorts.

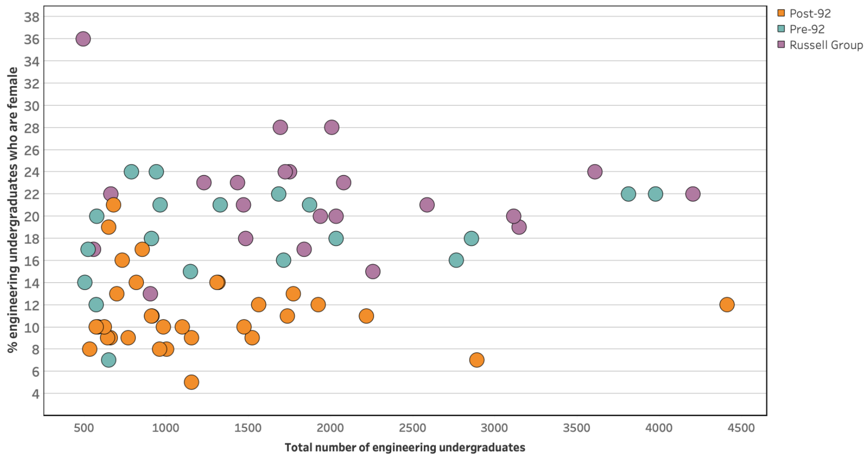

Fig. 4. Percentage of UK students who are female in all undergraduate disciplines as a function of the total UK undergraduate engineering cohort

3.4 Requirement for physics

The underrepresentation of women on engineering courses has long been associated with the low percentage of girls taking A-level physics (Engineering UK 2020). Entry requirements for mechanical, civil and E&E undergraduate courses were gleaned from university websites for the 73 universities under consideration. In most cases maths was a prerequisite, but physics was only mentioned in a list of scientific or numerate subjects of which one was necessary. Thirteen universities had one or more programmes with physics A-level (or equivalent) stated as a requirement, seven of which are in the RG, five more are pre-92 with only one in the post-92 category.

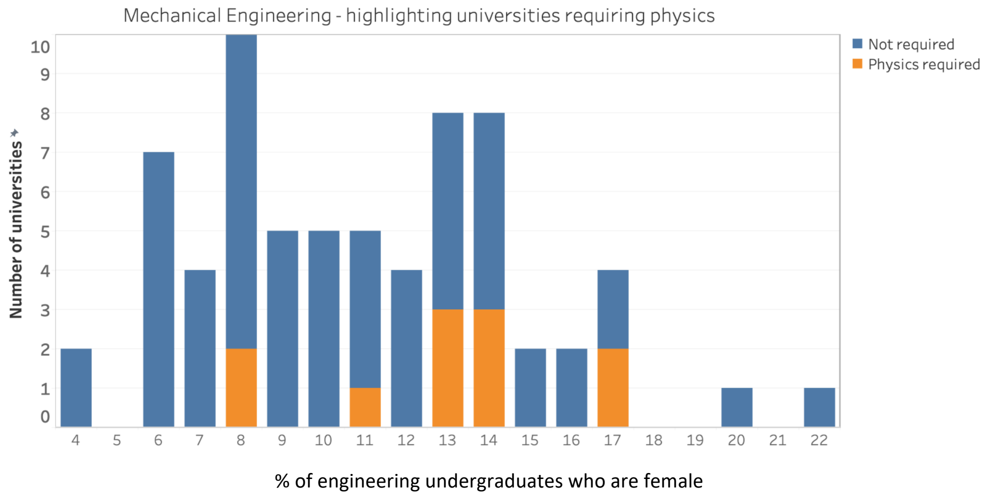

Fig. 5. Distribution of universities by percentage of UK students who are female, highlighting those with a requirement for physics on any engineering programme.

If a university *does* require physics, this is usually for their mechanical engineering programmes. It could be hypothesised that these programmes will have lower percentages of female students, as there is a smaller pool of young women from which the university can recruit. If this were the case, Figure 5 would show the universities highlighted as 'physics required' towards the left tail of the distribution whereas they appear across the breadth of distribution curve, implying the requirement for physics has no clear impact on a programme's gender balance.

3.5 Entry requirements

The final potential mediating variable is the academic achievement required prior to university, ie how good are the student's A-level grades (or equivalent). To make a comparison, the specified subjects are ignored and account only taken of the grade levels required, which are then converted into 'UCAS tariff points' (UCAS 2023). As shown in Figure 6, where each circle represents an individual HEI, students with the lowest tariff will only have access to a small number of post-92 universities. As the tariff achieved increases, gradually more post-92s and then the pre-92s are accessible, with RG requiring the highest tariff points.

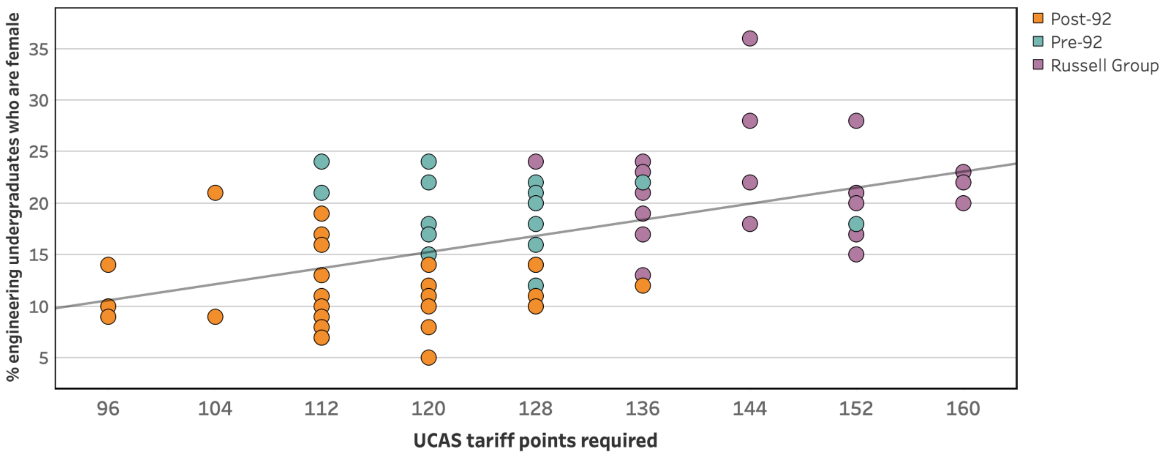

Fig. 6. Percentage of UK students who are female in all undergraduate disciplines as a function of the entry requirements in UCAS tariff points

While caution is necessary when considering regression analysis due to the existence of outliers and because the distribution of universities by percentage of engineering students who are female gives a bimodal rather than a normal distribution, Tableau's line of best fit (p-value < 0.0001) suggests that the representation of women increases with the level of the required entry tariff points. Assuming a relationship exists between the perceived prestige of a university and the tariff required to apply (Foskett 2010), it can be inferred that, broadly, the higher the university's status, the higher the percentage of women on the engineering courses.

4 CONCLUSIONS

The distribution of UK universities by percentage of engineering students who are female (Figure 1) is bimodal, suggesting pre- and post-92 HEIs as two distinct categories. In general, the higher a university's status (equating to academic selectivity) the larger the proportion of women. Female representation is independent of the number of engineering students but is dependent on the disciplines offered by a university. Of the five most populous disciplines, BMB engineering has the highest percentage of women, followed by chemical and civil, with mechanical and E&E the lowest. Only 18% of universities require physics for one or more of their mechanical, E&E or civil engineering programmes and this does not appear to deter female enrolment.

The results support Codiroli McMaster's (2017) identification of a link between family SES and female STEM study, which could be due to the perceived risk associated with breaking stereotypical boundaries. Reduced science (or STEM) capital could also play a role (Archer et al 2015). Females with lower academic qualifications may lack both self-efficacy and identity if engineering is equated with being either nerdy or a genius (Starr and Leaper 2019). Alternatively, perhaps men are *overrepresented* in the 'new' universities - more options may be open to women who possess suitable mathematical ability while also having good verbal skills, while the men with lower verbal skills have fewer options (Wang, Eccles and Kenny 2013).

From a statistical point of view, the best way to improve a university's representation of women in engineering is to drop mechanical and E&E programmes and increase the numbers on BMB courses. Clearly this is not a recommended solution and is a reminder to be wary of quantitative analysis without context. More realistic recommendations for recruiters are to worry less about girls taking physics A-level and to take an intersectional approach when promoting engineering, recognising the different circumstances and priorities of those without the highest academic achievement.

This study has been limited by FPE and rounding in the HESA data and the lack of relevant university categories. Future study could address these issues while monitoring changes in successive academic years both to indicate change over time and to establish natural variation in gender balance within individual universities.

This scoping study has revealed that some universities with lower academic entry requirements have a gender balance equivalent to more prestigious universities, particularly those HEIs with smaller engineering cohorts, suggesting that the individuality and agency of both the HEIs and the potential students merit further study. Future research could go beyond the HESA data and explore the influence of university outreach programmes, 'women in engineering' groups, diversity accreditation such as Athena SWAN, part-time offerings, employer links and placement opportunities etc.

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