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'They're not girly girls': an exploration of quantitative and qualitative data on engineering and gender in Higher Education

Abstract:

Despite sustained efforts to promote engineering careers to young women it remains the most male dominated academic discipline in Europe. This paper will provide an overview of UK data and research on women in engineering higher education, within the context of Europe. Comparisons between data from European countries representing various regions of Europe will highlight key differences and similarities between these nations in terms of women in engineering. Also, drawing on qualitative research the paper will explore UK students' experiences of gender, with a particular focus on the decision to study engineering and their experiences in higher education.

Keywords: Women; engineering; quantitative research; qualitative research.

1. Introduction

In the face of sustained efforts to promote engineering careers to young women it remains the most male dominated academic discipline, both in terms of numbers and culture. Women's access to higher education (HE) in the UK has significantly increased since the 1970s, and this has impacted on the number of women in all subject areas at university. Despite the general trend towards more women in higher education subject choice remains gendered. There are subjects in which women are the clear majority; education, in subjects allied to medicine, languages, linguistics, classics and related (all these have more than 70% women on course acceptances in 2008 [UCAS, 2009]). In comparison, engineering experienced only 13% women acceptances for the same year. It is understood that there are many reasons for this disparity – teaching in schools, socialisation, image of subject, culture of engineering – which have been explored by researchers (see for example; Alpay et al., 2008; Carter and Kirkup, 1990; Evetts, 1998; Fernandez et al., 2006; Madhill et al., 2007; Powell et al., 2004; Woolnough, 1994). This paper will also offer a brief comparison between UK data and other European countries - Spain, France, Austria, Lithuania and Serbia – these countries were chosen to represent different regions in Europe. Questions such as these will be addressed; which sub-disciplines attract more women? Is this

the same for the other European countries in the sample? What are the similarities and differences between nations? What is happening over time?

In addition to the quantitative analysis, we also analyse qualitative interview data collected in the UK that highlights some related issues with regards to women in engineering around questions of education and career choice and experiences in and of HE that remains overwhelmingly male, in student numbers, departmental staff and in the profession. The inclusion of interview data allows a better understanding of the varying factors that impact on overall trends that we can see in quantitative data and brings to the fore the experiences of the young women and men embarking upon a career in engineering. The interviews seek to explore student experiences and perceptions about studying engineering. The choice of what subject to study is still deeply gendered, as demonstrated by the statistical indicators on students in higher education. The interviews will explore discipline choice to try to extend understanding of this complex issue. Once the decision to study engineering has been made a series of factors can influence the subsequent decision to pursue a career in engineering. In particular, research has explored the academic culture dominant in engineering departments and higher education institutions finding that the masculinity of cultures reflects those found in industry and there is sometimes denial about any problem with regards to women's interaction with these masculine cultures (Lewis et al., 1999; Walker, 2001, Xu, 2008; Zengin-Arslan, 2002). We hypothesise that gender remains a salient organising idea for students, despite womens' (conscious and uncounscious) attempts to move beyond stereotypical gender boundaries.

2. Methodology

The quantitative data was collected from each country in the sample – UK, Spain, France, Austria, Lithuania and Serbia, making use of nationally available statistics in the respective country with a specific focus on gender and subject of study. The kind of data available from nation to nation can be

variable, with some nations collecting data from a variety of sources at the national and European level, but we have focused upon information in this paper that is available for all countries in order to make a meaningful comparison.

The quantitative data analysis brings to the fore a number of aspects that require further investigation. One way of delving deeper to develop a greater understanding of the varying factors that come to bear on the decisions young people make with regards to the university programme and clarify and illustrate meanings to the statistical indicators outlined above is through a qualitative enquiry (Robson, 2002). The qualitative data were collected through in-depth, semi-structured interviews¹, in order to uncover engineering students' thoughts and feelings about their educational decisions and experiences in their own words. Interviews also provide the opportunity to follow up interesting ideas and unforeseen avenues of enquiry (Murphy et al., 1998). In this paper we will focus upon the UK interviews only as there is not the space to also include an in-depth comparison between the qualitative data in the different European countries that were compared in the quantitative data analysis.

In the UK, the interviewees were accessed in liaison with the academic department in which their programme was based. In total 24 interviews with students took place at 4 Universities – with 12 female and 12 male students, all within Civil Engineering departments. In the UK Civil Engineering is the third highest engineering subject area by student enrolments (following Mechanical and Electrical and Electronic Engineering), with a higher percentage of women than these more popular disciplines. In 2010, there were 4796 students accepted onto Civil Engineering degree programmes in the UK². The four institutions involved represent both 'old' and 'new' universities in the UK, varying in ranking and research and teaching intensity. We only interviewed students who were in the second, third or final year of their programme as this meant they had more experience to draw on and the

¹ The qualitative data analysed for this paper focuses on UK respondents only

² Source: www.ucas.ac.uk

questioning would therefore be more fruitful. The interview questions were designed to cover the widest possible range of students' experiences – from their decisions to study engineering, their experiences on the programme, reflections on the curriculum taught and gender balance in the staff and student body – and be open so interviewees could elaborate according to their own experiences. In order to meet requirements of ethical guidelines for research with participants in the UK particular forms had to be completed and signed off before approaching institutions and we had to circulate participant information sheets and informed consent forms to participants prior to interview. The pre-requisite in the UK of ensuring informed consent necessitated the complete disclosure of the gender research intention of the interview. All interviews were recorded and transcribed and brief notes were made by the researcher during the interview.

3. Overview of quantitative data

3.1 UK data

UCAS data on UK HE students in 2008 show that 5.2% of acceptances in HEIs (Higher Education Institutions) were onto engineering courses, and 2.3% on architecture, building and planning. This can be compared to 12.2% for business and administration studies, 10.8% for creative arts and design and 9.5% for subjects allied to medicine. Over the period of 2003-2008 the proportion of students accepted onto engineering has declined slightly (from 5.8% in 2003), and risen slightly for architecture, building and planning (from 1.9% in 2003). Looking specifically at women's participation in higher education and engineering education over nearly four decades using HESA (Higher Education Statistics Agency) and UKDA (United Kingdom Data Archive) data we can see clear trends emerging. Firstly, women's access to higher education in general has increased significantly, from 32% in 1972 to 55% in 2008. Secondly, we can see that women's participation in engineering education has also increased from 4% in 1972 to 18% in 2008³. Figure 1 demonstrates that the increase in women's participation does not rise as sharply as women's participation in higher education during this period and

³ Data on students in subject groups 'engineering' and 'architecture, building and planning' have been added together to produce engineering student statistics in this paper.

may account for the increases in women's participation that engineering education has experienced. Bagilhole et al. (2005) argue that the increase in the number of women studying engineering is, in part, attributable to the rise in female students across all university disciplines. It should also be noted that during the period of 1972-2008 there has been an overall decline in the proportion of students in engineering as a percentage of all students – from 16% in 1972 to 7% in 2008. Further, a closer analysis of women's participation in higher education in comparison with participation in engineering disciplines demonstrates that the proportion of women in higher education pursuing engineering subjects is now at the same level as the early 1970s at just over 2% (see figure 2 below).

With regards to engineering professionals in the UK we can see that women's participation in these fields are increasing; government statistics show that women as a percentage of engineering professionals has risen from 4% in 2001, to 7% in 2008; and for architects, planners and surveyors the figure has risen from 12% in 2001 to 19% in 2008⁴. The UK's Engineering Council figures on membership data also indicate significant rises in percentage terms of women registered with them, however, these 'sharp' rises were derived from a small base figure of 0.5% in 1988 (see table 1).

3.2 Comparisons between European statistics

As we can see in table 2 there are similarities and differences between the statistics for the countries in our sample; Austria, France, Lithuania, Serbia, Spain, and the UK. These countries were selected to represent those from across the regions of Europe (North-South, East-West), differing sized nations, differing socio-political histories, and in order to be able to make comparisons across Europe and meaningful analysis at a pan-European level. In most countries women now make up over half of the HE student population, but make up a much smaller proportion in engineering and technology, ranging from 18% of students in the UK, to 35% in Serbia. The

⁴ Derived from Labour Force Surveys 2001 - 2008, Employment by occupation and sex.

fact that greater female presence in higher education does not result in greater equity in the numbers of men and women in engineering and technology is demonstrated in wider European trends outlined in the latest *She Figures* (2009), statistics published every three years by the European Commission on gender and science in the European Union. The differences in national figures on women in engineering suggest that the particular social context can have an effect on how far society perceives engineering to be an option for young women, whether engineering careers are promoted to women and in turn how far women themselves opt for this path. Despite the variance between the data on women in engineering across countries, we can see that women are universally less likely to enrol on engineering courses at university than men.

For all students and also within engineering, women make up a greater proportion of graduates than students (except for engineering graduates in France), which may be caused by changes in female representation over the time period from initial enrolment to graduation⁵, or this could suggest that once women have embarked upon a university programme they are more likely to complete it than men. This may be due to the conviction of female students who have already jumped through particular cultural hurdles and perhaps thought through the decision more thoroughly than male counterparts who may have seen engineering as a more 'obvious' choice following on from mathematics and science education. This 'commitment' factor requires further investigation. It is also interesting to look at the percentage of women in HE who are on engineering programmes across the sample countries: this figure ranges from 1% and 2% for France and the UK, to 15% and 31% for Serbia and Lithuania. For some countries the percentage of women on HE engineering courses has remained at similar levels over long periods of time, and overall trends in enrolment across European countries in our sample can be seen to be converging – overall enrolments are in decline and women's enrolments are increasing, thus accounting for the proportional increase in women in engineering across all countries.

⁵ For confirmation of this trend it would be necessary to carry out a detailed longitudinal cohort study of female enrolment to graduation.

We can see that women are over-represented in particular disciplines within engineering, in particular in architecture, chemical engineering and agricultural engineering. There are sub-disciplines that have attracted more women in some countries and not others – for example, in Serbia over 70% of Technology and Metallurgy students are women and in Lithuania 71% of those registered in bio-engineering programmes are women. Looking at the other end of the spectrum we can see that women are consistently under-represented in mechanical engineering and electrical and electronic engineering across all countries in our sample. These kind of data do not tell us why this is the case; to some extent the literature (see for example, Cockburn, 1985; Daudt and Salgado, 2005; Godfrey-Genin, 2009) does refer to ideas about feminine disciplines within engineering or 'feminine' approaches to engineering, which is usually described as engineering that emphasises social imperatives.⁶ Also 'feminine' engineering education can be linked to more holistic, interdisciplinary content and methods (Faulkner, 2000; Alha and Gibson, 2003)⁷. Variances across the countries in our sample by sub-discipline may be accounted for in the varying cultural and socio-political histories, for example the post-communist countries overall have much higher rates of female enrolment, arguably due to the soviet emphasis on the value of equality in education, or particular gender stereotypes that may be culturally specific or articulated varyingly across the different countries in the sample.

Not all countries were able to provide detailed statistics on ethnicity and socio-economic background of female engineering students. Where these are available we can see that there is no clear picture of the intersection between gender and ethnicity. In Austria, students from America, Asia and other European countries had a higher proportion of women than 'home' students –

⁶ Constructions of women's unsuitability for sciences have not prevented women entering biological and medical sciences (Crompton and Sanderson, 1990), as these are perceived to represent the more caring and socially relevant disciplines in the sciences. However, women in these 'feminised' areas of science tend to hold positions of a lower grade, have fewer opportunities for promotion up the organisational hierarchy and lower pay than their male colleagues, showing that 'getting in' is not necessarily the same as 'getting on' (Fielding and Glover, 1999).

⁷ For more information about recent developments in this field of research see <http://www.fp7-helena.org/conference2011/>

though this data refers to nationality rather than ethnicity. In the UK, engineering has a slightly greater ethnic mix, but architecture, building and planning have proportionately more women across all ethnicities.

With regards to socio-economic background of engineering students, again data was rather limited. However, we can see that in the UK, higher social class students (higher and lower managerial and professional qualifications, groups 1 and 2) are more represented as a proportion of applicants and also acceptances for all students, with this trend being slightly more pronounced for female applicants.

4. What the students say – experiences and perceptions of gender

4.1 Decision to study engineering

A key theme articulated in the decision to study engineering was the importance of peers and the family. It seems to be of particular importance for female students that family were generally supportive of their decision to study engineering, though sometimes not as well informed about engineering as other subjects, such as medicine, or law. In some instances students cited the influence of having direct contact with engineers in the family. In addition, it was highlighted in the interviews that significant family members perceive maths and sciences to be 'proper' subjects and this seems to be taken on board by male and female students alike, as is reflected in their subsequent choice of study subject. Some female respondents remarked how their peers were surprised when they found out they were going to study engineering, for example one respondent stated;

'My family were very happy, they didn't mind, they liked that I was doing a, as they called it, a proper subject, engineering or science. But my friends, I went to an all girls' school, so they were a bit shocked I was choosing engineering, to them it was a boys' subject. Even my teachers were shocked that I was going to do engineering' (female).

This kind of response reflects those from other female students interviewed – the surprise of peers, a lack of involvement of the school in encouraging this

path, and the importance of a supportive family network- who tend to confer status and value to a scientific field of study.

4.2 Experiences as an engineering student

Once we had discussed the influencing factors of their decision to study engineering we asked respondents about their experiences on their programme of study with a particular focus on gender. Student impressions of the gender balance on their programme and in their department were muted and many felt that the gender balance had no impact on their experiences;

'I don't really see it as male and female, I suppose that's why I went into engineering because I don't see that divide' (female).

The idea that *gender is irrelevant* to the students interviewed was most evident in responses to direct questions about gender and perhaps this represents a dominant 'common-sense' discourse on the subject. When asked whether the gender mix on their course impacts on their experiences (learning and non-learning) all male students, except one, reported it made no impact on their learning. However, in the wider discussion around this theme it does appear to impact on perceptions and experiences. Male students tended to comment on the social impact on the proportion of male:female students, suggesting that all-male groups work and behave differently once females are included;

'having some girls in the group - there is less tension and a little bit lighter and a more friendly environment. I think the mix is important' (male).

Four male students indicated that they would like more female students on the course for social reasons.

Despite the perception that female engineering students do alter the social dynamics, this may have more to do with male responses to mixed gender situations and stereotypes than direct experience of female engineering

students. It was often remarked that the girls in engineering are not 'girly girls', both by themselves and by the male students – importantly this is implied by all to be a desirable phenomenon.

*'Quite often the women are not 'girly girls', so you don't notice it a lot.
You don't treat women very differently to men really' (male)*

The undermining and downplaying of femininity is articulated by all engineering students. However, female engineering students cannot get around this simply by not being a 'girly girl': there are regular reminders of their 'other' status in engineering from academic staff and other students. One respondent provides some examples of gendered experience;

'Some girls find jokes and swearing difficult A bit of joking and banter can be a problem e.g. being told in a seminar to 'take clients out on a gentleman's evening seminar to get the brief so you can design it'. And you get comments such as 'Did they take you on here because you are female?' (female)

Half of the female students reported the male dominated gender mix had impacted on their experiences on the course, and all in relation to their learning. Of these students three reported that being a female was an advantage as female students tend to work together to help each other unlike male students and female students are often better leaders. Four students reported negative experiences as a result of their gender. Some of these experiences were strongly discriminatory. For example one student said female students were told they should wear skirts by a lecturer to get a better mark in a presentation. A further female student said she was told explicitly by one lecturer that women should not be engineers.

4.3 Perceptions of the possibility of improving the gender balance in engineering

All but three students (male and female) explicitly said that they believed women should be encouraged into engineering in some form (e.g. at school).

About half of these students (equally male and female) who were positive about women being encouraged into engineering also expressed some concern that women were not “pushed” or “forced” into engineering if they were not interested or competent in the subject. Of the students who were not explicit about encouraging women into engineering, one female student was concerned that women should not be favoured above men. Similarly a male student was concerned that encouraging women into engineering in some way would mean women were perceived as getting an easier path into engineering than men, which could count against them in industry. In sum, the concern for both males and females when questioned about encouraging women into engineering was in the effects of positive discrimination rather than in any belief that women cannot be engineers.

When asked to reflect upon the obstacles for women going into engineering (inside and outside university) there were some gendered differences in the answers given. Most male students tended to believe that the male domination of the industry simply puts women off, along with social and cultural expectations from friends and family. By contrast, most female students reported that a lack of role models in the industry was an important factor along with a lack of marketing (or promotion) of engineering to women in schools and universities. Notably, more women (two) than men (one) believed that essential biological differences between the sexes (e.g. different mental capacities) is an obstacle for women going into engineering. One female student, for example, believed male brains to be more logical than female brains.

5. Discussion and conclusions

The statistical indicators on engineering students in Europe demonstrate that in most countries women now make up over half of the HE student population, but make up a much smaller proportion in engineering and technology. Despite the fact that the greater proportion of HE students are women, engineering is far from reaching parity with regards to numbers – particularly

in the UK. Thus, it is evident that in using engineering as an example gender differentiation by discipline remains despite women's access to higher education. Research has tried to investigate why this is the case and why some women choose a discipline that seems to be in opposition to, or at least have some friction with, their sex. It has been found that the decision to study engineering is influenced by interests and ability, knowledge of the subject (Gale, 1994), the chance to gain hands-on experience (Madhill et al., 2007; Woolnough, 1994) and 'contact' with engineering (Cockburn, 1985). STEM (Science, Technology, Engineering and Mathematics) subjects at school level are crucial in terms of access to engineering higher education, in terms of a child's ability (Alpay et al., 2008), success, confidence and self-efficacy. Key factors that impact on the decision to study engineering are as follows; information about engineering being available, direct contact with engineering – via family members (Alpay et al., 2008); background and socialization – middle-upper class (Cockburn, 1985), supportive parents (Godfroy-Genin's, 2009); and personality – self image and gender identity, motivations (Alpay et al., 2008; Evetts, 1998; López Sáez, 1994) or 'acts of rebellion' (Carter and Kirkup, 1990: 40-41). It has also been found in research that perceptions about engineering can have an impact on whether a young adult will decide to study engineering once they have achieved success at school level (Phipps, 2002). Identified perceptions include; that it is a 'man's subject' (Agapiou, 2002; Cronin and Roger, 1999; Bagilhole et al., 2007; Sagebiel and Dahmen, 2006); that it is more difficult than other subjects; it is for 'geeks' or 'nerds' (Institute of Engineering and Technology, 2008); that it does not offer a pathway to an interesting or lucrative career.

The data presented shows that despite some progress in the numbers of women entering engineering programmes, this may be the result of general trends towards increasing numbers of women entering HE as a whole. The complex interrelation of the factors impacting on young people's decision making require further investigation in order to fully appreciate why (or why not) young women choose engineering disciplines. The interviews with students provide an insight into the experiences of women engineers and how their experiences can be gendered, in spite of a rejection of gender as an

organising principle. In addition, as European statistics on gender demonstrate a variance between sub-disciplines within engineering and between nations, further research could explore specific engineering cultures, whether mechanical, civil, electrical and electronic or civil engineering.

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