From subject choice to career path:

Female STEM graduates in the UK labour market

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Abstract

Increasing the number of women in the STEM labour market has been presented by policy makers and industry representatives as an opportunity to address purported skill shortages in the sector. National governments have spent considerable sums on initiatives aimed at increasing the proportion of girls and women who study science and work in STEM jobs, with a particular focus on increasing the number of female STEM graduates.

Although there is a considerable literature on gendered patterns of STEM education, the employment of recent STEM graduates, and gender pay gaps in the STEM workforce, there are important gaps in our knowledge about the position of STEM graduates. We combine several high-quality large-scale data sets to provide a comprehensive overview of the relationship between gender, STEM degree subjects and employment destinations in the first decade of this century.

We found that labour market destinations were closely linked to undergraduate STEM subject choice but that gendered differences persisted within subject areas. Throughout their early and mid-careers, women with STEM degrees were more likely than their male peers to be employed in 'caring' professions such as health and education, be employed in 'lower status' associate professional positions, and less likely to hold managerial positions.

Keywords: STEM, gender, labour market, graduates, employment

Introduction

In recent years, improving the recruitment, retention and training of the next generation of Science, Technology, Engineering and Mathematics (STEM) professionals has been a priority for policy makers and employer organisations in the UK, the USA and beyond (e.g. National Academy of Sciences 2020, BSA 2021, Royal Academy of Engineering 2017).

Although there are a number of challenges to the claims of a crisis in STEM education and a subsequent shortage of suitably qualified STEM workers (Teitlebaum 2014, Smith 2017, Smith and White 2018a, 2018b) one area that has received repeated and widespread scrutiny is the recruitment of highly-skilled female graduates to the STEM sector. As discussed below, attrition occurs at each stage of the STEM 'pipeline', from fewer girls opting to study science at school to smaller numbers of female scientists working at the highest levels (Beede et al. 2011).

In this paper we contribute to the empirical evidence on gendered inequalities in STEM education and STEM careers by comparing the careers of female and male graduates in the UK. Using the highest quality secondary data available, we focus on the period from graduation through to later careers.

We address the following research questions:

- To what extent did the labour market outcomes of male and female STEM graduates vary in relation to:
    a) Rates of employment and unemployment?

b) Employment in graduate-level jobs?

c) Employment in highly-skilled STEM jobs?

d) Employment in managerial and professional positions?

- What were the differences in the types of occupational roles that male and female STEM graduates undertake?
- How did these patterns of labour market participation differ for male and female STEM graduates from their early twenties through to their later careers?

The policy context

> Women's increased participation in the STEM workforce is essential to alleviating the shortage of STEM workers.
>
> (U.S. Congress Joint Economic Committee 2012, 5)

> Failure to start improving the way in which girls and young women are encouraged to study in subjects like physics, mathematics and engineering reduces the size of the talent pool and potentially jeopardises the international competitiveness of engineering and manufacturing in the UK.
>
> (NCUB 2016, 2)

Industry and policymakers have expressed concern about the under-representation of women in STEM education and occupations for many decades (e.g. House of Representatives 1959, NSF 1980). However, as the above quotations show, recruiting more female scientists is viewed as a means to overcome perceived shortfalls in the numbers of STEM workers and is motivated by economic concerns rather than a desire to include more women in important and fulfilling careers (e.g., NAO 2018).

In 2014, a UK government Science and Technology Committee inquiry into women in scientific careers in the UK reported that its investigations had ‘not uncovered any new issues on the topic of gender diversity in STEM subjects’ and concluded that ‘the problems and solutions have long been identified, yet not enough is being done to actively improve the situation’ (HM Treasury/BIS 2014:53). Arguments that are echoed in recent inquiries by policymakers into diversity in the STEM workforce which suggest that gender inequality persists and that progress has been hampered by a lack of active engagement by key stakeholders (BSA 2021).

These arguments sit uneasily with the substantial sums that have been spent on initiatives aimed at increasing female participation in STEM over the past 40 years or more. Either these initiatives are not sufficiently informed by the evidence, or it is actually the case that the ‘problems and solutions’ have not yet been identified.

As we discuss below, the evidence base is patchy and mixed, stronger in some areas than others, and there are still important gaps in our knowledge in the area (Emsi 2018). While it is true that it is well established that women are under-represented in STEM education and the STEM workforce *in general*, there is much less evidence about how this plays out in terms of links between studying (or not studying) particular subjects and working (or not working) in particular types of jobs.

The labour market outcomes of female STEM graduates

Despite the long history of research into gendered participation in STEM education, and the vast amount of literature published in this area, there is an imbalance in the evidence available in relation to labour market outcomes, with some topics being much better served than others. For reasons of space, we restrict our discussions to large-scale analyses of graduate outcomes; although, as we have discussed elsewhere, non-graduates make up the majority of the highly skilled (HS) STEM labour force (Smith and White 2018a).

Early career outcomes of female STEM graduates

Perhaps because relevant data are more widely available, the majority of research on the labour market destinations of STEM graduates – male and female – focuses on the first jobs they enter shortly after graduating. It is also the case that most of this work uses data from the US but a consistent finding is that women's under-representation in STEM occupations can largely – but not wholly – be accounted for by the subjects they studied as undergraduates (Sassler et al. 2017a). Their low levels of participation in engineering and computer sciences are particularly important in this respect, but even those women who studied these subjects were less likely to work in STEM than their male peers. This is part of a wider pattern, with female STEM graduates less likely than males to pursue a career related to their subject of study (Xu 2013). Among those who continue to pursue their studies at the postgraduate level, women are more likely than men to work in academia and government and less likely to work in industry (Buffington et al. 2016).

The longer term career trajectories of female graduates

Although there is much less research on the later careers of graduates, there is some evidence that, in the UK, early occupational destinations are reliable predictors of later career trajectories (Dolton and Vignoles 2000). In the US, where again there is much more research in this area, graduates are unlikely to change their field in the first ten years after graduation (Xu 2013) but women in STEM careers are more likely to leave their field than other professional women, even though they are no more likely to leave the labour market in general (Glass et al. 2013). The earnings of US men and women diverge further later in their careers, largely because of the family commitments that are overwhelming taken on by women (Xu 2015). Among US STEM workers, 43% of new mothers left full-time employment after having their first child compared to 23% of new fathers (Cech and Blair-Loy 2019).

The degree subjects and labour market sectors in which women are most underrepresented are associated with the largest gaps in both pay and participation. In the US, engineering and computing occupations make up 80% of STEM employment but have the lowest proportion of female employees (Landivar 2013). These are also the employment sectors with the largest gender wage gap (Sassler et al. 2017b). Pay gaps have also been found in other STEM occupational areas, however, such as chemistry (e.g. Broyles 2009). Although these findings are for STEM workers in general – rather than graduates in particular – they have implications for the careers of graduates with degrees in associated subjects.

What we still don't know

The available evidence suggests that female STEM graduates' careers differ in important ways from those of their male peers. They are less likely to enter STEM jobs, less likely to stay in the sector, and are likely to be paid less than their male peers. However, as noted earlier, there are several limitations in the current evidence base in terms of its geographical and temporal coverage, and the level of detail about degree subjects and career destinations.

Most of the studies used data from the US and there is much less research looking at the situation in other countries. Even within the US, many studies focused on pay gaps at the expense of other aspects of women's careers (e.g. Olitsky 2013, Thorton and McDonald, 2015). While there has been some research in Germany (Klein 2016), Australia (ACOLA 2013), Italy (Croce and Grignoni 2020) and the UK (Britton et al. 2016, Sullivan et al. 2018), these studies either focus mainly on wage gaps, look only at recent graduates, or are not primarily concerned with gender differences. Studies focusing on the occupational outcomes of female STEM graduates at all stages of their careers are relatively uncommon outside of the US and most of these studies mostly only examine destinations shortly after graduation. Many data sets lack information on the subjects graduates studied (or majored in) and so can only compare STEM degrees as a whole with degrees in other subjects, or at best look at very broad subject groupings.

In this paper we aim to fill this gap by providing a more granular analysis of the labour market participation of female STEM graduates at the beginning of this century. Unlike many of the other studies in the area, by drawing on data from several sources, we were able to: examine both immediate post-graduation destinations and longer term career paths; differentiate between STEM subject areas; and assess job outcomes according to different measures and criteria.

Data and Analysis

We used several, high quality secondary data sets in this research. These represent the best data available on STEM careers in the UK. Each data set provides a different perspective. They include: population and sample data; aggregate and individual-level data; and cross-sectional and cohort data. Combined, our original analyses of these data sets have allowed us to produce by far the most detailed existing overview of long-term, gendered patterns of participation in the STEM labour market in the UK.

One of the key benefits of these data sets is that the data on occupational outcomes was directly comparable up until 2012. However, after this point the data collected was not directly comparable between the different data sets, so our analyses were unfortunately limited to this endpoint. More information on this issue can be found in Smith and White (2018).

We describe the data sets in more detail below:

HESA Destinations of Leavers from Higher Education

The UK Higher Education Statistical Agency (HESA) First Destinations survey gathered data on every UK graduate approximately six months after they have left university. Respondents were asked about their employment status and whether they have embarked upon further study. Response rates for the survey were high – typically around 80% (HESA 2013) – and data were published in aggregate form. Our analyses included data on more than 3 million graduates from the academic years 1994/5 to 2010/11. HESA changed the definitions of a number of key categories in later years, meaning that the 2010/11 academic year is last year for which data are available that are comparable with those from the previous two decades.

The 1970 British Cohort Study

The 1970 British Cohort Study (BCS70) follows the lives of around 17,000 individuals born in Great Britain in one week in April 1970, who were aged 42 in 2012. We used data from five sweeps of the study in the analysis presented here and provide a detailed account of the cohort members' careers at ages 26, 30, 34, 38 and 42. Response rates were over 70% for most sweeps (see: Smith and White 2018a). The data for the sweep at age 42 were collected in 2012 and were the latest data at the time the research was carried out.

Annual Population Survey (APS)

The APS is a national cross-sectional survey that includes key variables from the Labour Force Survey. The survey first took place in 2004 and we analysed data on 25- to 64-year-olds from 2004, 2006, 2008 and 2010. As variation between the patterns in each year of the APS was very small, we combined data for all four years, creating a data set with more than 800,000 cases. This allowed us to disaggregate the data in greater detail and examine the relationship between individual degree subjects and participation in particular jobs.

Patterns of participation in the graduate labour market

Before we consider patterns of entry into the work force in detail, it is useful to briefly examine the STEM subjects that undergraduates studied at university. HESA data from 1986 to 2010 show that although, at the end of the first decade of the 2000s, more women than men enrolled on undergraduate programmes at British universities, gender stereotyped patterns of participation persisted in many STEM subject areas. As more women have entered university, several subjects have seen their share of female undergraduates increase and around half of all STEM undergraduates are now female. However, women are still greatly underrepresented in the engineering sciences (in 2010/11, 88% of undergraduates were male) and slightly overrepresented in the biological sciences (in 2010/11, 57% were female). Much of the increase in the proportion of women studying STEM subjects has been a result of increased recruitment to the allied medical sciences subject group (in particular nursing, which is now a graduate qualification in the UK). We discuss these patterns in more detail elsewhere (Smith and White 2018a). In the next section we examine how these unequal patterns of participation translate into labour market outcomes for STEM graduates.

Early career graduates in the labour market: graduate-level employment

The vast majority of graduates from all subjects either entered employment or pursued further study. HESA data show that the proportion of graduates who were unemployed sixth months after graduation varied slightly between 1994/95 and 2011/12, with female graduates slightly less likely to be unemployed (between 4% and 7%) than male graduates (between 6% and 12%) and slightly more likely to be in employment (between 66% and 71%) compared to males (57% to 72%) in most years. Around a fifth of all students continued to further study in the first year after graduation.

As most graduates entered employment or further study shortly after graduation, it is useful to focus on differences in the types of jobs that they worked in. While there is debate about what constitutes a ‘graduate-level’ role (see: Elias and Purcell 2004), classifying jobs according to this criterion can be helpful in identifying differences in the kinds of positions taken up by different individuals and groups.

What might be considered to be a ‘graduate job’ has changed over time. Although there is no clear consensus on this matter, Elias and Purcell (2004) have devised a classification in which graduate employment covers most occupations falling into SOC categories 1–3 (Managerial, Associate/Professional and Technical). Non-graduate employment, on the other hand, is predominantly made up of roles that fit into SOC categories 4–9 (Administrative and Secretarial, Personal Service, Sales and Customer Service, Machine Operatives and Elementary Occupations). Elias and Purcell’s classification offers a theoretically and empirically grounded classification that has been validated using existing large scale data sets.

Other, perhaps even more sophisticated classifications of graduate employment are available. Green and Henseke (2016) offer an alternative and provide a detailed overview and critique of the most some of those that are available. Unfortunately, for the most part these require data that are not available in all the data sets used in this project and so could not be used, for comparative purposes, in this research. However, the differences between these classifications largely relates to *types* of graduate job – rather than whether a job is graduate-level or not. Because of focus here is the comparison of graduate with non-graduate roles, the exact classification used would be unlikely to impact dramatically on the overall conclusions drawn from our analyses.

In most STEM subject areas higher proportions of men entered graduate-level work than women, but the extent of the gap varied. Computer Science had the largest difference, at around 12 percentage points for some years (Figure 1). There was a smaller gender difference among Engineering Science graduates, but men were consistently more likely to be employed in graduate-level occupations. This was also the case for biological science graduates and those with degrees in the mathematical sciences (not shown).

INSERT FIGURE ONE HERE

Because of the different rates of participation in STEM subjects, the subject-level differences in graduate-level employment have implications for the labour market outcomes of male and female graduates. The subject areas with the highest rates of graduate employment were those dominated by male students and vice versa. However, there were gendered differences in outcomes even within these subjects, with recent female graduates consistently having lower levels of graduate-level employment. While the size of these differences varied between subject areas, these gaps persisted over the first decade of the 2000s and showed no signs of diminishing.

Early career entry into highly-skilled (HS) STEM[1] jobs

Rates of graduate-level employment are one, rather limited, indicator of the 'value' of a STEM degree. However, as we discussed earlier in this paper, a perennial concern of policymakers and industry bodies has been HS STEM occupations, and a lack of suitably skilled workers to fill these jobs. These concerns have led to policies and initiatives aimed to increase the number of STEM graduates, who are presumed to be most likely to have the skills for these positions. Increasing the proportion of women studying STEM in higher education – particularly in subject areas where they are traditionally underrepresented – has been seen as central to achieving this aim.

Our analysis of HESA First Destinations data shows that, among those with STEM degrees, male graduates were considerably more likely than female graduates to secure employment in HS STEM jobs: around a third of men but less than 20% of women entered this type of employment within six months of graduation. As was the case with graduate-level employment, there was considerable variation between subject areas.

As can be seen in Figure 2, much higher proportions of male than female engineering graduates found work in HS STEM jobs (64% compared with 44% in 2010/11). Although not shown here for reasons of space, similar patterns were evident in the computer sciences (see: Smith and White 2018a), demonstrating that the two most male-dominated STEM subject areas also had the largest gender gaps in early graduate destinations to HS STEM jobs.

INSERT FIGURE TWO HERE

The proportion of Biological Sciences graduates entering HS STEM jobs within six months of graduates was noticeably lower than for those with degrees in Computer Sciences or Engineering Sciences, and this difference was more pronounced than that for graduate-level employment seen in Figure 1. There was little difference between male and female Biological Sciences graduates, but the proportion of graduates from this subject area entering HS STEM jobs shortly after graduating tended to be less than half the rate for the Physical Sciences and only one third the rate for Engineering Sciences graduates.

In terms of the ‘STEM pipeline’, these patterns raise two issues. First, women were less likely to study the STEM subject areas from which the largest proportions of graduates go on to work in HS STEM jobs. Secondly, those women who did gain degrees in male-dominated areas such as Engineering were less likely to work in HS STEM jobs than their fellow male graduates. The largest gender gaps in both HS STEM employment and undergraduate enrolment were found in the very male-dominated Engineering Sciences and Computer Sciences, smaller gaps were found in the less male-dominated Physical Sciences, and there was almost no gap in the Biological Sciences, in which more female than male students enrolled.

Occupational destinations for recent STEM graduates

While policymakers may be concerned with the number of graduates entering HS STEM positions, graduates themselves vary in terms of their career goals. Although examining the proportions of graduates entering graduate-level and HS STEM roles is useful, these categories are broad and can obscure important differences between the labour market destinations of male and female graduates. In this section we look in more detail at the types of jobs that STEM graduates enter shortly after graduation.

Table 1 shows SOC2000[2] occupational destinations among STEM graduates six months after graduating, for the last three years of the HESA data we analysed. We have focused on a selection of job categories that are either historically important in terms of policy and, or, are areas where there are clearly gendered patterns of participation.

There were some striking differences between the rates of employment of male and female STEM graduates in different types of jobs. Employed male STEM graduates were roughly twice as likely to be in Managerial (SOC1) positions as their female peers and are considerably more likely to work in Professional (SOC2) roles (although this difference is smaller). As a result, employed female STEM graduates were much more likely to be working in lower status Associate Professional (SOC3) jobs.

There were also interesting differences in the areas that male and female STEM graduates find work. Among those working in Professional roles, employed female STEM graduates were more likely than males to be working as Health Professionals, but much less likely to be employed as ICT or Engineering Professionals. These differences largely reflect the subjects they study as undergraduates but highlight the ways in which choices earlier in the 'pipeline' impact on later career trajectories.

Perhaps the most telling evidence of entrenched gendered patterns of participation in the graduate labour market is provided by the differential rates of employment in Associate Professional positions in the medical and health sector. These lower status positions, often in 'caring' roles such as nursing, were much more likely to be held by female STEM graduates. In some years female STEM graduates were nearly *nine times* as likely as males to be employed in these jobs. This is in stark contrast to the IT and Engineering Professional roles, discussed above, that had the same disparities, but in favour of male graduates.

INSERT TABLE ONE HERE

Occupational destinations of later career STEM graduates

So far, our discussion has focused on the labour market positions of STEM graduates six months after graduation. As noted earlier, because of the availability of data, there is much more evidence on the occupational destinations of recent graduates than there is on their later working lives.

This is an important omission. People change jobs during their careers, work in different sectors and take on different roles. In this project we used Annual Population Data to examine the occupations of STEM graduates aged between 25 and 64 in the first decade of the 2000s. The individual-level data and large sample size allowed us to disaggregate between both subject areas and job types for male and female STEM graduates.

As can be seen in Table 2, the vast majority of STEM graduates of all ages were employed in graduate-level positions and there was little difference between male and female graduates in this respect. There were, however, small differences between male and female graduates in all the main subject areas, with male graduates having a slight advantage.

The larger proportion of employed male STEM graduates working in management roles shortly after graduating was replicated in the older workforce. There was a difference between rates of employment in Production Manager and Function Manager roles, however, with women much less likely to go into Production Manager roles. Production Manager role are much more closely tied to manufacturing and scientific industries, while Functional Managers work in a wider range of sectors (such as human resources, marketing and human resources). So, while female STEM graduates were generally underrepresented in management roles, they were particularly underrepresented in management roles in science and industry.

As was the case with recent graduates, the differences in rates of employment in HS STEM jobs were more pronounced. Among STEM graduates aged 24 to 64, 55% of employed males worked in HS STEM occupations compared to only 32% of females. Gender gaps among Engineering Sciences and Computer Sciences graduates were relatively large, and the smallest gap was among Biological Sciences graduates, who also had the lowest rates of participation in HS STEM occupations. This picture broadly reflected that of recent graduates. Importantly, in both data sets we observed little substantial change in these trends over time.

INSERT TABLE TWO HERE

The patterns of participation in particular STEM occupations among the older workforce showed similar gender divisions to those seen in recent graduates. Overall there were only small differences between the proportions of STEM graduates working as Science Professionals but in other areas there were large imbalances in the participation rates of male and female graduates. Some of these, such as the overall proportion of STEM graduates working as Engineering or Computer Science Professionals, reflected the gendered differences in participation between STEM subject areas. However, proportional analysis shows that even when their unequal numbers as undergraduates is accounted for, male Maths and Computer Sciences graduates were four times more likely than females to be working as Science or Engineering professionals. Female STEM graduates from all four STEM subject areas in Table 2 were more likely than males to work as Health Professionals but, as was the case with recent graduates, the differences in recruitment to Associate Health Professional posts was striking. Overall, female STEM graduates were 16 times more likely to be employed in these occupations.

Degree subject and gendered employment patterns

Our final analysis looks at the relative advantage or disadvantage of gaining a STEM or non-STEM degree for male and female graduates. We have seen in the preceding sections that the career outcomes for men and women are similar in some ways and different in others. What can we say, however, about the extent to which taking a STEM degree – rather than a qualification in a non-STEM subject – has different results, in terms of employment destinations, for men and women?

INSERT TABLE THREE HERE

Table 3 shows APS data on the proportions of male and female graduates, with degrees in STEM and non-STEM subjects, who were employed in graduate-level jobs. As was noted above, the vast majority of all graduates worked in graduate-level jobs at any particular point during this period. Graduates with STEM degrees were slightly more likely to work in graduate level jobs than those with degrees in other subjects, but this difference was smaller for men than it was for women. The relatively advantage, in these terms, for women with STEM degrees compared to those with non-STEM degrees was thus larger than it was for men. However, this difference was not a large one.

INSERT TABLE FOUR HERE

As can be seen in Table 4, it is also the case that the majority of graduates held managerial and professional roles (SOC2000 groups 1 and 2), regardless of their sex or degree subject. The differences between outcomes for male and female STEM and non-STEM graduates, however, were quite different to those observed in relation to graduate level employment. Whereas male STEM graduates were more likely to be employed in managerial or professional roles than their peers with non-STEM degrees, the opposite was true for women. Female STEM graduates were actually less likely to be employed in SOC 1-2 roles than women with degrees in non-STEM subjects. This was evident in the data in terms of a much larger gap between male and female STEM graduates than between men and women with degrees in other subjects. This difference was largely accounted for in the greater proportion of women working in associate professional and administrative positions (SOC 3-4).

INSERT TABLE FIVE HERE

It would be very surprising if having a degree in a STEM subject was not associated with being employed in a HS STEM occupation. We can see from Table 5 that this was the case for both male and female graduates but that the relative difference between men and women was different. We have already shown that a greater proportion of male STEM graduates held HS STEM positions compared to female STEM graduates.

However, male STEM graduates were 2.75 times more likely to work in HS STEM occupations than men with degrees in other subjects. Female STEM graduates, in comparison, were four times more likely than women with non-STEM degrees to work in HS STEM roles. The disparity in the participation of STEM and non-STEM graduates in HS STEM roles was much greater for women, meaning that taking a STEM degree was a more important factor for women than it was for men in determining entry to the STEM workforce.

The careers of STEM graduates

At the beginning of our discussion of our findings we examined participation in STEM education among undergraduates and their occupational destinations six months after graduation. Next we looked at patterns of employment of graduates aged 24 to 64. In this section we look at the labour market participation of a single cohort of graduates from age 26 to 42. This provides an idea of how people's occupations changed over the course of their careers.

Across all five sweeps of the BCS70, from age 24 to 42, over 50% of male STEM graduates worked in HS STEM jobs. But for female STEM graduates the figure is around twenty percentage points lower at each sweep of the study. For example, at age 30, 61% of male but only 39% of female STEM graduates were working in HS STEM jobs. Movement out of HS STEM jobs by both males and females over time meant that, proportionally, this gap grew slightly as cohort members progressed through their careers. A similar gender gap is apparent when non-STEM graduates were included in the analysis, suggesting that regardless of degree specialism, men were more likely to work in the HS STEM sector than women at every stage of their career.

In contrast, the proportion of cohort members in graduate-level positions increased slightly as the cohort members aged. At age 26, 84% of male and 82% of female STEM graduates were in graduate-level jobs and this rose to a peak of 92% and 91% by age 34 and remaining around 90% for the next eight years. Looking in greater detail at types of destinations revealed greater gender differences, however. Almost twice the proportion of male STEM graduates were in Managerial (SOC1) positions at age 26 (16% vs. 9%) and, although this gap closed as cohort members got older, there was still a 31% to 21% difference at age 42. The gap in Professional (SOC2) employment was relatively small at age 26 (54% vs. 51%), and had disappeared by age 38 but, as was the case with both the HESA and APS data, female STEM graduates were much more likely to work in Associate Professional (SOC3) occupations. This gap was remarkably stable over the survey sweeps, ranging from women being between one-and-a-half to two times as likely to be employed in these positions.

Summary

Before discussing the implications of our research, it is worth briefly summarising our key findings. Our work has gone beyond the scope of previous studies, not just in terms of bringing different datasets for the same time period together, but also in terms of the granularity in terms of degree subjects and types of employment.

Increases in participation in science at undergraduate level in recent decades have largely been along traditionally gendered lines. More women have studied science over the last few decades, but increases have largely been restricted to the biological sciences, subjects allied to medicine, and other subjects such as psychology. Little has happened that has disrupted traditional gendered patterns of participation.

There were relatively large, and persistent, differences in the labour market outcomes of female and male STEM graduates in the year after graduation. Female STEM graduates were less likely than their male peers to: gain graduate-level employment; work in HS STEM jobs; and work in managerial positions. These differences were largely related to differential rates of participation in different STEM subjects, but within-subject differences were evident, and they were largest in subjects that are the most male-dominated. The largest difference in outcomes were in HS STEM employment, but female graduates were also much more likely to work in lower status 'caring' positions than are their male peers.

While the majority of all older graduates eventually were employed in graduate-level jobs, fewer women than men held management roles, regardless of age, and those who did were less likely to work in science and industry. The differences in HS STEM employment were evident across the entire graduate workforce and, as was the case for new graduates, gender differences were greatest among those with degrees in male-dominated subjects.

The relationship between degree subject studied and occupational outcome varied according to gender. Holding a degree in a STEM subject was more important for women compared to men in terms of gaining graduate level employment and working in an HS STEM role but was associated with a decreased probability of working in a managerial or professional role. Studying STEM was generally advantageous for men, in terms of these kind of employment outcomes, but was not always associated with higher status occupations among women.

Analysis of our cohort data showed no evidence of the gender gap in HS STEM employment closing as cohort members' careers progressed. Female STEM graduates appeared to 'catch up' their male peers in terms of professional-level employment but more men held managerial jobs and more women were employed in lower status associate professional jobs at any point up to age 42.

Discussion

At the beginning of this paper we noted that increasing the number of female STEM graduates, and raising their rates of participation in the STEM workforce, has been presented as a solution to the purported STEM skills shortage. Leaving aside the debate about the nature and extent of this 'shortage' (Smith and Gorard 2011, Smith 2017) our findings, viewed alongside other research in the area, raise some questions about the likelihood of this strategy being successful.

As discussed earlier, and explored in detail elsewhere (Smith and White 2018b, Smith and White 2020), recruitment to 'shortage' STEM degree subjects has been flat, not just in relative but also in absolute terms, for decades, despite the expansion in undergraduate participation more generally. Initiatives to increase female participation in science at all levels have been notable for their lack of success in making any large and sustained impact on levels of recruitment in both education and the labour market.

As our analyses have shown, female STEM graduates were generally less likely than their male peers to work in STEM jobs, and educational participation among women was highest in the very subject areas that had the lowest levels of graduate employment in the STEM workforce.

Whereas – at least at the aggregate level – there appeared to be a small career advantage for male STEM graduates, compared with graduates with degrees in other subjects, this was not the case across all measures for female STEM graduates. As such, there is less grounds for encouraging women to take STEM degrees on the basis of improved career outcomes. Although there is evidence to suggest a small gain in terms of graduate level jobs, female STEM graduates have lower status outcomes than their non-STEM peers in terms of managerial and professional roles. Taking a STEM degree appeared to be more important for women than men in terms of working HS STEM jobs, but female graduates were still much less likely to take up these positions regardless of the subject they studied.

As our data cannot tell us about the reasons qualified women do not enter the STEM workforce, there may be scope – as recent policy documents suggest – for more to be done to persuade women of the benefits of working in science. However, putting aside the important fact that previous interventions taking this approach have not shown great promise, existing research suggests several aspects of working in the STEM sector that would make it unattractive to women. A considerable gender pay gap exists within scientific careers (Xu 2015, 2017) and it has been widely reported that women studying and working in the male-dominated STEM sectors face a toxic culture of discrimination and harassment, and are overlooked for promotion (Little 2020).

Although the issues discussed here are not unique to working in STEM, they offer plausible explanations for the lack of sustained success of initiatives encouraging increased female participation. If their experiences of studying STEM – and their experiences in their first jobs – are discouraging women from pursuing careers in the field, the traditional model of increasing supply at all stages of the ‘pipeline’ will not translate into long term participation in the sector. Given that the vast majority graduates – regardless of degree subject or gender – went on to work in graduate-level and/or high status positions by the time they are thirty, female STEM graduates are likely to have many employment opportunities that appear more desirable than those offered by employers in the STEM sector. Perhaps only fundamental reform to the structure of the reward system and the occupational culture will change these patterns of participation.

Moreover, emerging research into the impact of COVID-19 on STEM careers points to an exacerbation of inequalities as women shoulder the greater share of household and caring duties (Australian Academy of Science. 2021, RSC 2021). Such situations might present policymakers with an opportunity to rethink more radically their approach to managing the STEM ‘pipeline’. As governments now seek a return to economic growth, the long-term perspective on the occupational trajectories of the STEM workforce presented here makes a timely contribution to this debate.

Notes

1. We use the UKCES (2015) definition of highly-skilled STEM jobs.

2. SOC2000 rather than SOC2010 was used to ensure comparability with older data.

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