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Academic Careers in SET in the UK: The Gendered Experiences and Career Progression of PhD Students and Postdoctoral Researchers

by

Anna-Lena Vallentin

Birkbeck, University of London

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Introduction

The purpose of this working paper is to provide an overview of research on the experiences and career progression of women in SET disciplines. The focus is on PhD students and postdoctoral researchers in the UK. Despite an overall increase in women obtaining PhDs in SET (Science, Engineering and Technology) subjects across Europe, this has not translated into more women in senior scientific positions in either academia, or the private or government sector (European Commission, 2013). This has been a concern for UK policy makers for years. In 2014, the House of Commons Science and Technology Committee concluded that despite multiple incentives and initiatives, women remain underrepresented at senior levels in every science discipline (House of Commons, 2014).

Research has stressed the importance of the PhD experience for a career in science (Etzkowitz, Kemelgor, & Uzzi, 2000; Roberson & Bigler, 2013; Stobbe, van den Brink & van Duijnhoven, 2004). Women tend to describe a more negative experience, particularly in relation to supervision, exclusion from informal networks, and a lack of female role models and mentoring opportunities (De Welde & Laursen, 2011; Etzkowitz, Kemelgor & Uzzi, 2000; Ferreira, 2003; Fox, 2001). Not surprisingly, the transition from PhD student to postdoctoral researcher has been identified as a critical period during which a significant amount of women disappear from scientific careers (Royal Society for Chemistry (RSC), 2008a). In addition to the psychological and economic insecurity of temporary employment, which make this career stage precarious for both men and women, there are gender specific obstacles that women experience during this stage.

While there is some research on undergraduate experiences in SET subjects from a gender perspective (see e.g. Powell, Bagilhole & Dainty, 2011), research on the experiences of PhD students and postdoctoral researchers is still scarce in the UK context (Zalevski & Swiszczowski, 2009). Funding bodies have only recently developed an interest in monitoring the career progression of scholarship recipients and equality concerns are being identified (RSC), 2008a; RSC, 2008b; RSC, 2008c; Wellcome Trust, 2012). Despite this increasing interest in PhD students' experiences, this research has mainly been quantitative and focused on a few disciplines only. Furthermore, the experiences of postdoctoral researchers remain particularly underresearched (Zalevski & Swiszczowski, 2009).

This working paper starts with an overview of research on academic scientific careers and current theory on gendered cultures in higher education institutes. It then provides an outline of the UK context and recent statistics on women and men at different academic career stages in SET disciplines. This will be followed by a review of research on the gendered experiences of PhD students and postdoctoral researchers in SET. The paper concludes with an overview of the UK policy background and current initiatives to address gender imbalances in academic careers in science.

Academic SET Careers and their Gendered Implications

Academic careers have traditionally been understood as linear trajectories (Wolfinger, Mason & Goulden, 2009). A typical academic career in the UK moves from PhD student to postdoctoral researcher to a permanent lecturing post and then to senior grades such as senior lecturer, reader and professor through promotion (Kirkup, Zalevski, Maruyama & Baltool, 2010). In reality, an academic career can take various shapes and be influenced by institutional factors such as a focus on research or teaching (Kirkup et al, 2010). More importantly, the social background of academics including gender, ethnicity, disability and class can have a significant impact on an academic career. For example, women's academic careers are more likely to be interrupted by career breaks and part-time work (Brouns & Addis, 2004). This affects not only many women's publication records but also their capacity for taking on extra responsibilities. Serving on committees, networking during evenings and weekends, travelling abroad to conferences or taking up a guest lecturer post at another university are difficult to manage for people with caring responsibilities. The traditional academic career assumes a disembodied, male worker who can devote all of his time to his profession (Acker, 1990). It is structured according to a masculine norm of success, which rewards frequent publishing, inclusion in the Research Assessment Exercise (now REF), and an uninterrupted career trajectory (Knights & Richards, 2003, p.213).

While claiming to be based solely on the principle of meritocracy, the academic career system is in fact disadvantaging women. Bailyn (2003) notes that the principle of meritocracy assumes that

> women can follow this model as easily as men, and, if they do, will be seen as successful and as central as their male colleagues. Neither of these assumptions is true (p.139).

A number of studies have documented that women are often disadvantaged by informal practices and traditions which have been shaped by male academics. Wennerås and Wold (1997) have famously shown that a presumably equality-based practice such as using selection panels for the granting of postdoctoral fellowships favoured male applicants, particularly those who were part of the committees' network. Also, more recent research has shown that informal practices continue to undermine gender equality-related efforts in the selection of professors (van den Brink & Benschop, 2012). This research illustrates how women continue to be discriminated against in the academic profession, even if not openly intended.

Gendered patterns are also reflected in the tasks that academics accomplish on a daily basis. They often perform multiple roles, including teaching, research, leading teams, applying for research grants, networking, supervising, acting as mentors and providing pastoral care. Research found that women tend to have higher teaching and administrative loads and are more likely to provide pastoral care for students (Bagilhole, 1993). This may have negative effects on women's publication records, while teaching and mentoring activities often remain unacknowledged.

While some authors argue that academia is a profession that allows reconciliation between work and family life, this differs considerably among disciplines and career stages. Science disciplines often involve working in laboratories and experiments may need to be monitored during evenings or weekends (European Commission, 2008a). Sallee (2011) states that engineering PhD students are expected to "relinquish their lives to the demands of science and their advisors" (p. 2010). They are required to put in long hours and have few

responsibilities outside the lab while principal investigators are largely exempt from this. One apparent gendered implication of this is that pregnant and breastfeeding women are prohibited to work with certain chemicals and their PhD research may need to be put on hold during this period. Postdocs, on the other hand, are under pressure to travel abroad to develop an international network (Leemann, 2010) and to publish frequently, preferably in high quality journals, in order to establish themselves in the scientific community. Thus, family considerations constitute a major deterrent from academic research careers for women at the early postdoctoral stages as this time often coincides with starting a family.

Another aspect that affects predominantly women's but increasingly also men's careers is scientists' tendency to be partnered with other scientists (Ackers, 2004; Schiebinger, Henderson & Gilmartin, 2008). According to Schiebinger et al.'s (2011) study on the experiences of dual career hires in the US this is particularly common for women in the sciences. As many as 83% of women who are in academic couples are in a partnership with another scientist compared with 54% of men. Many US universities and more and more European universities now offer dual career services. The practice of dual hiring at the same university is a common strategy in the US. However, men continue to be the majority of so-called 'first hires'. While some described positive experiences with this practice, being a second hire may have detrimental effects on one's career. Some respondents felt there was a stigma attached to being a second hire; that they were not as well-respected at their department and viewed as under-qualified. Some reported not being given sufficient lab space and financial resources as well as a salary below their qualification level. Having outlined how academic research as a career continues to be structured according to male working patterns, the following section will provide a theoretical background which focuses on the level of academic organisations.

Gendered Organizations and Practices in Academic SET

Instead of trying to 'fix' women to suit masculine work norms, current research focuses on understanding how gender inequality is reproduced through workplace cultures (Bagilhole, Powell & Dainty, 2008). This perspective represents a recent shift in studies concerned with the sociology of science in that it does not view gender differentiated socialisation as the main factor deterring women from working in science (Gilbert, 2009). Instead, it focuses on identifying gendered structures, practices and norms within individual organisations which often unintentionally discriminate against women (Martin, 2003).

Gendered Organizations

In *Men and Women of the Corporation*, Kanter (1977) notably developed the theory of tokenism. In this ethnographic study of a US company, she observed that women were clustered in lower paid jobs and assumed token status in senior positions. The female managers stood out in a group of mostly male senior managers and felt they needed to outperform their male colleagues to be recognised as capable managers. Another important aspect she observed was that 'token women' were perceived as representatives of women as a group and their behaviour was judged based on what was considered appropriate for women. More recent studies have described this last aspect as a paradox which also affects how women act and view themselves in their professional lives (Faulkner, 2011; van den Brink & Stobbe, 2009). Faulkner's (2011) ethnographic study of women in engineering workplaces concludes that female engineers are "perceived, and can feel themselves, to be not quite 'real engineers' or 'real women'" (p. 287).

Acker (1990) argued that Kanter's theory relied too heavily on numbers and did not specifically address the gendered nature of organisations. Furthermore, she argues that Kanter failed to acknowledge that the same effect could not be observed for token men who are more likely to be positively evaluated in women-dominated workplaces (Acker, 1990). Kvande (2002) found evidence for this effect at a public healthcare body in Norway. Despite being heavily underrepresented in this workplace, men were assigned management positions during a restructuring process. This ultimately reproduced traditional gendered divisions of work and power.

Acker's (1990) basic assumption is that organisations are not gender-neutral entities but that 'gendering' occurs along several dimensions. The first dimension relates to divisions based on gender, including divisions of work, allowed behaviours, use of physical space and location, and power. An example of this is that women are well-represented at junior levels but do not reach the highest ranks in academic careers. The second dimension relates to symbols and images, which illustrate and legitimate gendered divisions. These can be expressed through language, values and idealised behaviour, dress, but also within the wider societal context including popular culture, the media and education. Van den Brink and Stobbe (2009) postulate that images of science, scientific practice and the ideal scientist are among the most important factors that reproduce gender inequality at universities. The third dimension relates to the interactions among members of an organisation. Acker refers here to interactions between women and men, women and women, as well as men and men. Within the academic context, this can be related to the practice of homosocial bonding among male academics, which excludes women from informal networks (Leemann et al., 2010). The fourth dimension refers to a person's individual identity and how members of organisations internalise the three previous dimensions. This becomes particularly challenging for women in traditionally male-dominated workplaces. The above-mentioned study by Faulkner (2011) found that some female engineers dressed in an androgynous manner to assume a more masculine work identity, reproducing the hegemonic masculine culture of their workplace. Van den Brink and Stobbe (2009) observed a similar practice among female undergraduate students at an Earth Sciences Department.

Gendered practices

Gender as a practice in organisational research builds on Acker's (1990) framework and the notion of 'doing gender' (West & Zimmermann, 1987) which contends that enacting gender in everyday life is something that involves 'work'. West and Zimmerman (1987) explain that

> when we view gender as an accomplishment, an achieved property of situated conduct, our attention shifts from matters internal to the individual and focuses on interactional and, ultimately, institutional arenas (p.126).

A group of researchers in the Netherlands has studied gendered academic practices from this perspective in different science disciplines. Van den Brink and Benschop (2012) analysed how selection panels for professorships reproduced gender inequality through informal recruitment routines despite a formal commitment to gender equality by the university. Van den Brink and Stobbe (2009) conducted research on undergraduates' gendered course choices in Earth Sciences. They found that student advisors and students themselves viewed 'soft' science or socially-oriented courses as more suitable for female undergraduates. This research

highlights the importance of studying local practices in order to identify (unintended) discriminatory practices.

In the academic context, gender discrimination occurs in multiple forms and on multiple levels (van den Brink & Benschop, 2012). The authors postulate that this is the reason why gender equality initiatives are slow to gain a foothold in universities. They argue that there is no single academic practice but a multitude of localised practices since academic disciplines vary in their core activities, career patterns, publishing strategies, gender composition among students and staff and funding opportunities. Also national contexts have been found to shape academic careers and practice (Elg & Jönnergård, 2003). Krais (2002), describing academic practices in Germany, notes that in many university departments there is a tendency of what she calls the 'great personality model'. This means that the working methods and structures are shaped to a greater extent by 'great personalities' (often male senior academics) than by institutional regulations, undermining institutional efforts that aim to promote equal opportunities. Thus, gender dynamics operate within particular contexts with distinct structural and cultural characteristics. The next section will provide an outline of the current academic context in the UK and its gendered implications.

The UK context

There are several recent developments in the UK's academic system, which have affected men and women differently (Knights & Richards, 2003; Rees, 2004). Until 1992, there were two types of higher education institutions, universities in which staff undertook both research and teaching, and polytechnics and colleges of higher education which had a stronger emphasis on teaching. Since 1992, both types are called universities although often a distinction between pre- and post-1992 universities is made. Staff at previous polytechnics and colleges tend to have a higher teaching load and receive fewer research grants (Knights & Richards, 2003). This development has gendered implications: women are more likely to reach higher ranks at post-1992 (i.e. less prestigious) universities. Furthermore, the University and College Union (2007) found that the gender pay gap among academic staff was highest in pre-1992 ('old') universities (between 15 and 18.5%). In post-1992 universities, the gender pay gap among academic staff was only 6.8% on average in 2005/6.

Another important development is the Research Assessment Exercise (RAE), which was introduced in 1986 and coordinated by the four UK higher education funding bodies. It was a four- to five-yearly quality assessment of university departments' research output, requiring academics to provide up to four publications during the period in question (Knights & Richards, 2003). The outcome of the RAE informed the amount of funding each university received for its research activities. Researchers have commented that the RAE has fundamentally influenced the culture of academic departments as well as recruitment and promotion procedures. Academics are now assessed in relation to their potential of maximising the departments' score (Rees, 2004).

In the beginning, the RAE did not take into account the life situations of academics and as a consequence, men were almost twice as likely to be entered to the RAE in 1996 (Rees, 2004). In the following rounds, part-time work and career breaks including maternity leave were considered legitimate reasons for producing less than four publications. Nevertheless, gender imbalances continued in the RAE 2001 and 2008. Overall, 64% of male academics and only 46% of their female counterparts were selected for the RAE 2001 (Higher Education Funding Council for England (HEFCE), 2006). Particularly among staff between the ages of 35 and 55, men had markedly higher selection rates, indicating that men had progressed further in their careers in this age group. Furthermore, men were more likely to have published papers

over a certain field baseline in the majority of SET disciplines. Papers authored by men in these disciplines also had a higher citation count (HEFCE, 2006). To promote gender equality and diversity in the selection process, the funding councils issued guidance to review panels and higher education institutions between 2005 and 2007. Despite these efforts, HEFCE (2009) found that staff selection in the RAE 2008 was similar in gender composition to that in 2001.

The RAE has now been superseded by the Research Excellence Framework (REF) and under particular circumstances early career researchers can be included[1]. However, research assistants are not considered early career researchers unless they are principal investigators of a research project and are considered academic staff with a contract of employment of 0.2 FTE or greater. Although PhD students and the majority of postdocs are not included in the REF, it significantly affects their career development. They are under pressure to publish as much as possible from the very beginning. Furthermore, they need to consider the impact of their research as the REF evaluates departments based on research output (65%), research impact (20%) and research environment (15%).

External funding plays a major role in academic career development and it is a clear marker of success. Ackers and Millard (2009) analysed gender differences in numbers of submitted applications and awards of funding from the five UK science research councils[2] in 2007. Their analysis showed that women were slightly less successful in securing research grants and less likely to submit applications. For example, in Biosciences, a discipline in which women represented 29.5% of academic staff in 2006/7, 21.9% of project funding applications were submitted by women. Men had a 27.2% success rate while women had a slightly lower success rate of 23%.

SET Students by Gender

Female students' participation in SET undergraduate and postgraduate courses has been on the increase since the 1970s (Zalevski et al., 2009). Figure 1 and 2 show the increase of female students among full-time undergraduate and postgraduate students of Physical Sciences between 1994/5 and 2013/14. Particularly at postgraduate level, women's numbers have grown.

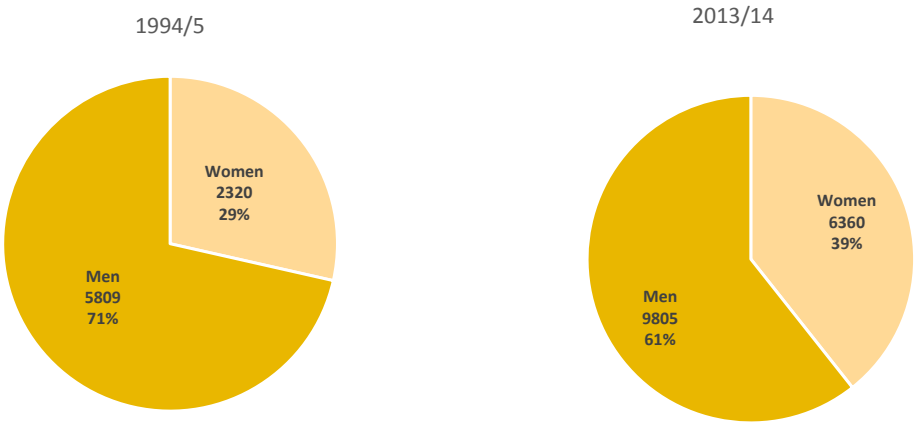
[1] Early career researchers are defined as members of staff who meet the criteria to be selected as Category A (academic staff with a contract of employment of 0.2 FTE or greater and on the payroll of the submitting HEI and whose primary employment function is to undertake either 'research only' or 'teaching and research') or Category C (employed by an institution other than a higher education institution) staff on the census date (31 October 2013), and who started their careers as independent researchers on or after 1 August 2009. http://www.ref.ac.uk/

2 The UK research councils for SET subjects are: The Engineering and Physical Sciences Research Council (EPSRC), the Science and Technology Facilities Council (STFC), the Medical Research Council (MRC), the Biotechnology and Biological Sciences Research Council (BBSRC), the Natural Environment Research Council (NERC).

Figure 1: Full-time Undergraduate Students in Physical Sciences

Data Source: HESA

Figure 2: Full-time Postgraduate Students in Physical Sciences



Data Source: HESA

By 2011/12 half of all SET students in the UK were female (50.9%). However, gender segregation across SET subjects persists: women are particularly numerous in subjects allied to medicine (79.5%), veterinary science (75.3%) and biological sciences (61.7%), while male students are in the majority in engineering and technology (84.3%), computer science (82.2%) and architecture, building and planning (67.5%) (ECU, 2013b). These large numbers of female students in some disciplines do not translate into high numbers of women professors, however. In biological science, women accounted for 45.9 per cent of researchers, 35.4 per cent of lecturers, but only 15.0 per cent of professors in 2007/8 (UKRC, 2010).

At PhD graduate level, women equalled or outnumbered men in all fields of study except for science, mathematics and computing (40%), and engineering, manufacturing and construction (26%) in 2010 (European Commission, 2013). In the UK, women made up 45% of all PhD graduates. However, the UK figures for female PhD graduates are slightly below the EU average in the fields of science, mathematics and computing (38%) and engineering, manufacturing and construction (22%). While women's participation in science education is

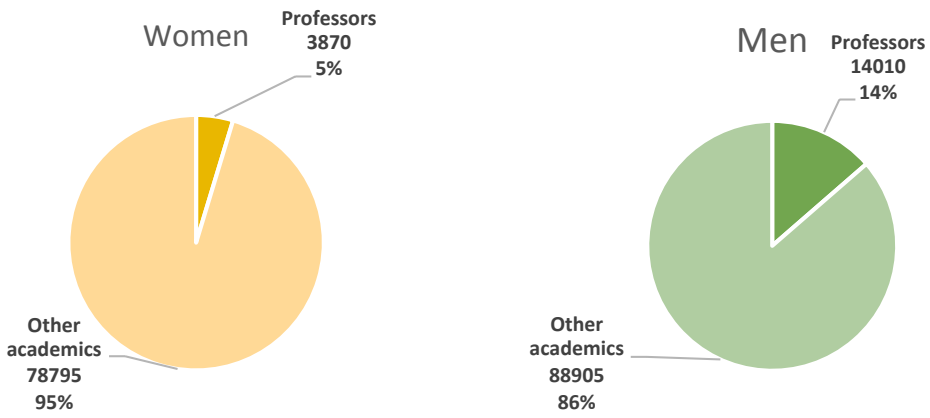
increasing, female graduates continue to be less likely to work in their field of study after graduation. Only 35.3 per cent of women with a degree in a STEM subject in employment were working in SET occupations, compared with 56.2 per cent of male graduates in 2008 (Kirkup et al., 2010).

Women and Men in UK Higher Education Institutions

At academic staff level, the number of women has also increased over the past decades. In 1992 women made up only 3% of professors and 6% of senior lecturers (Bagilhole, 1993). By 2011/12, women accounted for almost 22% of all professors. However, some science subjects continue to be almost exclusively male-dominated at the highest academic ranks: one in five Physics Departments in the UK still have no female professors (The Royal Society of Edinburgh, 2012).

In 2012/13 a total of 185,585 academic staff and 196,935 non-academic staff were employed at UK universities (Higher Education Statistics Agency (HESA), 2014). Women made up 44.5% of academic staff and 59.2% of non-academic staff. Female academics are more likely to work part time, 39.3% were employed full time and 54.7% part time. In addition to horizontal segregation across the different subjects, there is considerable vertical segregation among male and female academics. Although women make up almost half of the entire academic staff at UK universities, only 21.7% of all professors are women (HESA, 2014). Of all female academics, only 5% are professors, while men are almost three times as likely to be professors.

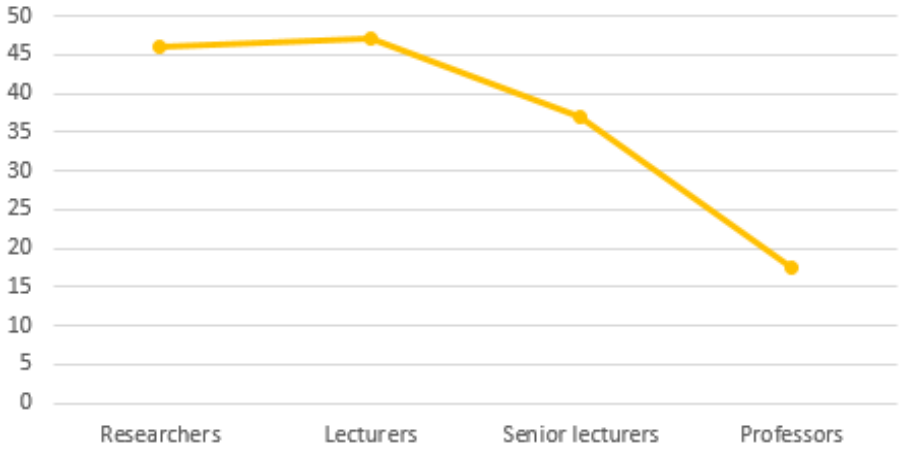
Figure 3: Professorial and non-professorial academic staff by gender in 2012/13



Data Source: HESA

HESA data does not distinguish between the different academic grades anymore but only between professorial and non-professorial status (Equality Challenge Unit (ECU), 2013a). Table 1 below shows that in 2006, when a breakdown across academic grades was still available, women accounted for 17.5% of professors, 37% of senior lecturers, 47% of lecturers and 46% of researchers (European Commission, 2013). Women are thus clustered in the lower levels of academic careers in the UK. This pattern is even more pronounced in SET disciplines as the next section will show in more detail.

Table 1: Proportion of female academics by staff grade in the UK in 2006



Data source: European Commission, 2013

On average, female professors earned 6.3% (£4,828) less than their male colleagues in 2011/12 (UCU, 2012). For all staff at higher education institutes in the UK, the mean gender pay gap was 19.0% in 2011/12 (ECU, 2013a). Furthermore, women were more likely to be on fixed-term contracts. As many as 38.5% of female academics (full-time and part-time combined) were on fixed-term contracts while the share of male academics on fixed-term contracts was 33.2% (HESA, 2014). Kirkup et al. (2010) note that the percentage of researchers on fixed-term contracts is very high in SET disciplines despite the introduction of the Fixed-term Working Regulations in 2006. Unfortunately, the statistics for individual disciplines are not available disaggregated by gender (Kirkup et al., 2010).

On a positive note, women's representation in university governing bodies is increasing in the UK.
Around 30% of members of governing bodies are now female and 20% of 166 governing bodies have reached a gender balance among their members (Jarboe, 2013). However, women continue to be underrepresented as Chairs and Vice Chancellors. Of 166 universities in the UK, only 28 are headed by a female Vice Chancellor and 20 governing bodies are chaired by women. Furthermore, Jarboe (2013) found that female Chairs are more likely to be found on governing bodies that have 40% or more women among their members.

Women and Men in Academic SET

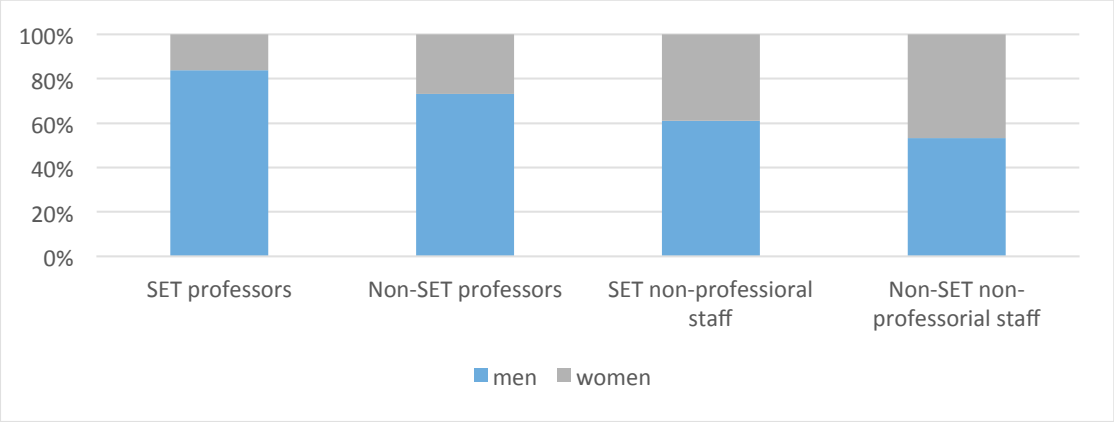
Academia is a significant employer for women in SET in the UK. As many as 44% of female scientific researchers[3] worked in higher education in 2009, 35% were employed in the government sector and only 19% in the business sector (European Commission, 2013). In 2011/12, the majority of female academic staff worked in non-SET subjects (51.4%). The opposite was true for male academics with 57.6% working in SET (ECU, 2013a). While

3 The term researcher refers here to no specific grade or type of occupation in higher education. The European Commission (2013) adopts the following definition: researchers are professionals engaged in the conception or creation of new knowledge, products, processes, methods and systems and also in the management in the process concerned.

these figures seem relatively gender-balanced, it should be noted that the definition of SET used by the Equality Challenge Unit (ECU) includes subjects allied to medicine in which women are overrepresented. When comparing the gender composition of the different SET subjects, it becomes clear that women are severely underrepresented in many of these reproducing the patterns found at student level. This is problematic since these are generally subjects that offer more stable and well-paid employment opportunities and are high in academic status (European Commission, 2013).

The only SET subjects in the UK in which women represent the majority of academic staff are nursing and paramedical studies (73.7%), psychology and behavioural sciences (59.0%), veterinary science (53.3%) and clinical medicine (52.0%). Women are particularly underrepresented in engineering subjects (ranging between 13.8% in electronic engineering and 21.7% in software engineering), physics (17.4%) and mathematics (22.6%). Figure 3 illustrates that the gender gap in professorial roles is larger in SET subjects than in non-SET subjects.

Figure 3: Women and men in professorial and non-professorial roles in SET and non-SET subjects in 2011/12

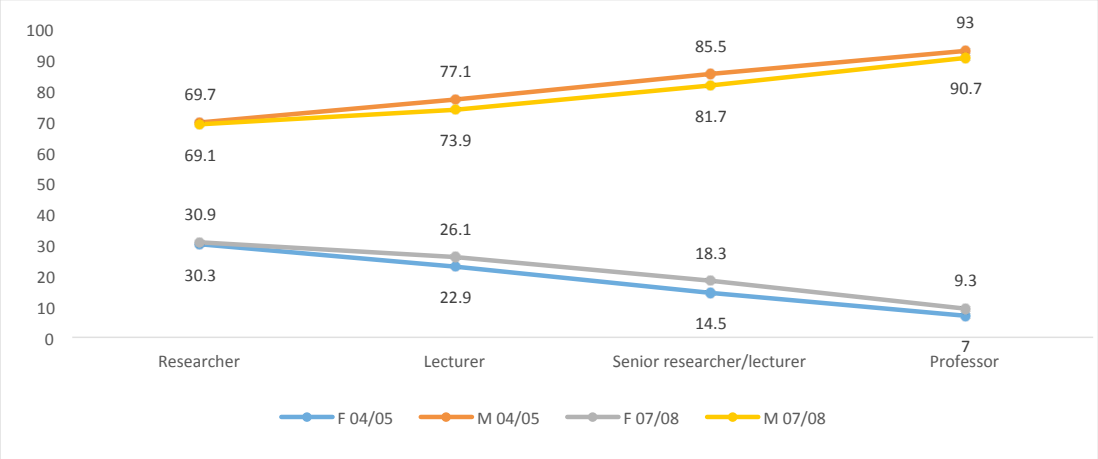


Data Source: HESA

As explained earlier, the most recent HESA data only distinguishes between professors and non-professorial staff. Previous data shows where women and men are distributed at all different academic ranks, providing a more nuanced picture. Figure 4 shows women's and men's representation in SET comparing data from 2004/05 with data from 2007/08. Women represent one third of researchers in SET disciplines and their proportion becomes progressively smaller at each successive career stage with only 9.3% being professors in 2007/08[4].

4 These figures are based on a secondary analysis of HESA data by the UKRC (Zalevski et al., 2009) which excludes subjects allied to medicine.

Figure 4: Distribution of SET academic staff in 2004/5 and 2007/8 by grade and gender



Secondary Analysis by the UKRC 2010, Data source: HESA (2008) Resources of Higher Education Institutions 2006/07, Cheltenham: HESA.

The gendered PhD experience in SET

The next part of the literature review is concerned with the hurdles that women experience at the early stages of a scientific career, which may ultimately prevent them from progressing in their careers. It should be noted that women's participation in scientific professions has seen a significant increase during the past 50 years. More and more women are studying and completing PhDs in SET subjects as the statistics in the previous section have shown. The number of women has increased at all career stages in academic SET disciplines. While in 1973, women accounted for 14.6% of postdocs in science and engineering in the US, they made up 39.4% in 2008 (Shen, 2013). At fulltime junior faculty level, there has been an increase from 11.3% to 41.9%. Women's participation at senior fulltime faculty increased from 6.2% to 26.8%, providing more and more role models for early career researchers.

Nevertheless, women continue to be underrepresented at senior scientific positions in academia and all other sectors. The doctorate has been identified as an important period for the development of scientific career paths (Etzkowitz, Kemelgor & Uzzi, 2000; Darisi et al., 2010; De Welde and Laursen, 2008; Roberson Hayes et al., 2013). A negative PhD experience has been found to affect future career planning and may result in the decision not to pursue a career in academic research (Goulden, Frasch & Mason, 2009; RSC, 2008a, RSC, 2008b). The PhD period is a time of socialisation into professional identity and of transition from being a student to becoming a professional (Ferreira, 2003). Research on women's and men's experiences of pursuing a PhD in science subjects has found that women tend to experience gender-specific obstacles. In the 1990s, a number of US studies of both quantitative and qualitative nature explored gender differences (see e.g. Etzkowitz, et al., 2000; Fox, 2001; Wolfinger, Mason & Goulding, 2009). These studies revealed that female PhD students often described a 'chilly climate' towards women at their institutions (Etzkowitz et al., 2000). Fox (2001) found that there were differences in the experiences at the level of departments, within research groups and with supervisors. Women reported that they were less likely to be taken seriously by academic staff, felt less comfortable speaking in group meetings and received less advice on how to design research, write grant proposals or how to

co-author publications. Women were also more likely to report having a student-faculty member relationship with supervisors than being treated as a colleague. Also more recent research suggests that women report more negative experiences during their PhDs including informal exclusionary practices, feelings of isolation, a lack of adequate female role models and structural barriers such as an academic career being in conflict with the timing of starting a family (De Welde & Laursen, 2011). This may have detrimental effects on a future career in science: Etzkowitz et al.'s (2000) large-scale study at 13 US universities found that female PhD students experienced a 'cumulative disadvantage', referring to past negative experiences which carry over to the next career stage.

Within the UK context, few studies have been undertaken to understand the experiences of PhD students in SET. Some funding societies have recently started to explore gender differences in the progression and career plans of PhD students. The Wellcome Trust, which funds research in health-related sciences, commissioned a longitudinal study on a cohort of PhD graduates in biomedical science. The 2012 report found that more women than men leave academia and that many do so directly after their PhDs. This suggests that the experiences during their PhD and/or the anticipation of postdoctoral research influences their career decisions (Wellcome Trust, 2012, p.13).

A number of studies have been undertaken by the Royal Society for Chemistry (RSC) in collaboration with the UK Resource Centre for Women in Science, Engineering and Technology (UKRC). These studies sought to understand why more women than men change their mind about pursuing an academic research career in chemistry and molecular bioscience. A survey on PhD students' career intentions showed that the proportion of women planning a career as a research chemist fell from 72 % in the first year to 37% in the third year. Additional qualitative research identified a number of issues that deterred female chemistry PhDs more so than their male peers from remaining in research. They were affected to a greater extent by standard supervision issues such as enjoying little guidance; encountered more significant supervision issues; experienced isolation and exclusion, partly caused by the culture of their research group; and had greater concerns about perceived poor experimental success (RSC, 2008c). A subsequent survey seeking to compare the career intentions of chemistry PhD students with those in molecular bioscience found that a larger proportion of women in bioscience were considering staying in academia after finishing their PhD than in chemistry (RSC, 2008b). The authors conclude that certain equality issues at the doctoral level may operate in chemistry but not in the molecular biosciences (RSC, 2008b, p.10).

Leemann (2010) points out that a career path should not only be understood in terms of institutional sequences such as education and different occupational roles, but also in the light of an individual's relationships and family, which affect career decisions. Family considerations and obligations are already relevant for PhD students' career planning but these issues have been found to significantly affect postdoctoral researchers (Zalevski et al., 2009). In a longitudinal study of the career progression of PhD graduates in Switzerland, Leemann (2010) found that during the postdoctoral phase, women are often disadvantaged in relation to international mobility and international networks. Their ability to move or travel abroad during their postdoc depends heavily on whether they have children and the type of partnership they are in. Ackers (2004) states that women tend to follow their partners and compromise their careers when their partner accepts a job abroad. Not only international

mobility may become problematic for postdocs; overall, the postdoctoral phase has been associated with a number of distinct concerns and gender-specific barriers, which are summarized in the following section.

Barriers to academic SET careers experienced by postdoctoral researchers

The route to a permanent post within academic SET varies between national contexts (Robin & Cahuzac, 2003), across disciplines and is affected by gender (Nerad & Cerby, 1999). In science subjects, postdocs often work in research groups which typically consist of a principal investigator, one or more postdocs and several PhD students. Postdocs conduct research on a specific topic under the supervision of the principal investigator, usually a senior member of academic staff. A postdoc's role often involves informal instruction and supervision of PhD students as well as teaching or taking on the role of a demonstrator in laboratory classes (Roberts, 2002). Furthermore, postdoctoral researchers may perform administrative tasks. Compared with the job requirements of PhD students, postdocs take on multiple roles. Provided that they are planning to pursue an academic career, their main concern is to develop their own research profiles and to establish themselves as autonomous members of the scientific community (Zalevski et al., 2009) - a task which often falls short in light of all the other formal and informal job requirements and which depends on the willingness of the principal investigator to support a postdoc's career development.

The Roberts report concludes that becoming a postdoc is not an attractive career path. The reasons are a "lack of clear career structure and uncertain career prospects associated with work on a short-term contractual basis" (p. 143). Another concern is that the overall length of the postdoctoral phase is increasing internationally, becoming a 'holding pattern' for scientists who are unable to find a permanent position in academic research (Laudel & Gläser, 2008). This has been attributed to a lack of permanent academic positions (Nerad & Cerby, 1999), also in the UK context (Zalevski et al., 2009). While short-term contract research offers advantages for universities, the consequences for postdocs' careers who may find themselves in an infinite series of fixed-term positions are daunting.

As described in the section on academic staff statistics, gendered career patterns can already be observed at the lower academic grades. There has been an increase in researchers at UK universities in recent years, coinciding with a shift towards greater female employment as researchers or postdocs (Glover, 2002; Roberts, 2002). The ratio of researchers in relation to the overall academic staff is particularly high in STEM subjects. While in 2000, researchers made up 28% of academic staff in all disciplines, it was 42% in STEM disciplines (Roberts, 2002).

The Roberts report put the problems faced by contract research staff on the UK policy agenda. As a response, the Fixed Term Employees Regulation was implemented in 2006. It legally obliged universities to treat staff on fixed-term contracts in the same way as permanent staff. Subsequently, the numbers of fixed-term contracts have declined (Zaleski et al, 2009). While in principle a positive change, the numbers of fixed-term contracts remain high in SET-related disciplines. Not surprisingly, job insecurity is perceived as the greatest downside of a postdoc position by physics and chemistry postdoctoral researchers (Dyer & McWhinnie, 2011). Dyer & McWhinnie's (2011) survey found that although the differences in postdocs' experiences between physics and chemistry were greater than gender

differences, some gender-specific experiences emerged. For example, female physicists were significantly more likely to select 'working long and irregular hours' and 'isolation', as a downside of postdoctoral research than male physicists. Similarly, a qualitative study of PhD chemistry students found that the "nature of 'postdocing' was the main factor discouraging female participants from pursuing academia in the short term more than anything else" (RSC, 2008b, p.34).

Zalevski et al. (2009) provide further examples of barriers for women postdoctoral researchers in academic SET disciplines in the UK. They argue that family considerations constitute a major deterrent from academic research careers for female postdocs because this career stage often coincides with starting a family. Whitelegg et al. (2002) found in their focus-group-based study of women physics PhD students and postdocs that women were aware of the fact that they may need to choose between a career and a family. The authors note that men do not need to negotiate a compromise between family and career to the same extent (Zalevski et al. 2009, Whitelegg et al, 2002).

Supporting this observation, a US study found that female postdocs in bioscience were less likely to be married and have children than their male colleagues but that they were more likely to experience childcare challenges (Martinez, 2010). While 30% of male postdocs expected their partner to make concessions only 15% of female postdocs expected the same from their partner. Furthermore, 42% of married women without children but only half as many married men without children stated that having children was a very important factor when deciding whether to pursue a principal investigator position. Plans for starting a family or having another child may already deter women from taking up a postdoc position after completing a PhD or applying for another postdoc contract. In fact, Whitelegg et al. (2002) found that female early career physicists believed that it was virtually impossible to take maternity leave whilst working as a postdoc on a funded project or whilst receiving a fellowship.

Besides family considerations and obligations, Zalevski et al. (2009) highlight the low organizational status of postdoctoral researchers as a barrier to academic research careers. This is often mirrored in postdocs being physically located in less central spaces in the research institute or department. Also here, gender specific experiences have been observed. Dyer & McWhinnie (2011) found that female postdocs in chemistry were more likely to feel like students than a member of staff compared with male respondents: 38% of the women and almost half of the male chemistry postdocs (47%) reported that they felt more like staff than students, while 23% of women and only 15% of men reported feeling more like students.

A closely linked and central issue is the principal investigator-postdoc relationship. PIs are central to a postdoc's career development in terms of networks, references and research output. Zalesvki et al. (2009) state that PIs often treat their postdoctoral research staff as personal assistants and ignored postdocs' needs for developing a profile as independent researchers. Moreover, gender stereotypes may be at play when postdocs start to compete with their supervisors in their fields; competitive behaviour may not be perceived as appropriate for a woman and their achievements may be treated differently than those of male postdocs. Furthermore, female postdocs in particular are often burdened with heavy administrative and teaching loads. Other issues affecting women postdoctoral researchers' career development include insufficient provisions for part-time work and contract sharing, a

lack of female role models and opportunities for networking, relentless competition among researchers for permanent posts and barriers to international mobility (Zalevski et al., 2009).

These are some of the reasons that researchers have identified as causing the 'leaky pipeline' effect which is commonly used to illustrate women's gradual disappearance from science careers at each career stage with only few women reaching senior positions (Blickenstaff, 2005). This loss of women from the science talent pool has become a concern for UK policy makers, and their response through various initiatives will be summarized next.

Policy Context and Current Initiatives

This section provides a brief overview of the policy developments, actors and initiatives involved in supporting women's careers in academic SET in the UK. A complete analysis is beyond the aim of this working paper. In 1993, the Science White Paper *Realising Our Potential* noted that women's talents were severely underused in the UK's scientific workforce. Subsequently, the *Promoting SET for Women Unit* was set up to develop policy-based research, to implement pilot projects and to support women in the science community (European Commission, 2008b). The work of the Unit was continued by the *Science and Society Unit* of the Department of Innovation, Universities and Skills.

Despite these initiatives, the Greenfield (2002) report on women in SET called for a strategic overhaul of the UK's science policy. The report stated that although more and more women were studying SET subjects at school and at universities, this did not translate into an adequate increase in women in science jobs. It further argued that there was no link between the increase in women studying SET and the over 70 initiatives that aimed at increasing women's participation in science education (Harding, 2009). In response to the report, the *Strategy for Women in SET* was implemented whose key objectives included the establishment of a resource centre for women in SET. The resource centre was provided with funds to support pilot schemes to raise the participation of women in the SET workforce (Harding, 2009).

Subsequently, the UK Resource Centre for Women in Science, Engineering and Technology was set up in conjunction with the Government's 10 year Investment Framework for Science and Innovation (2004-2014). The mission of the UKRC was to provide accessible, high quality information and advisory services to industry, academia, professional institutes, education and Research Councils within the SET and built environment professions, whilst supporting women entering and progressing in SET careers. In addition to the UKRC, the Equality Challenge Unit, the Athena Forum and the Athena SWAN Charter are supporting gender equality in academia.

The Equality Challenge Unit is funded by the UK higher education funding bodies and other funding organisations including science research councils. It provides a central resource of advice and guidance for the higher education sector including the monitoring of diversity and equality in relation to gender, race/ethnicity and disability among students and staff in all academic disciplines.

In 1999, the Athena Project was established by the UK Higher Education Funding Councils, Universities UK and the Office of Science and Technology, Department of Trade and Industry. Its aims were the advancement and promotion of the careers of women in science in higher education and research. One of its main activities was the Athena Survey of Science

Engineering and Technology (ASSET) survey, a national survey on the differences in the career progression, expectations and experiences of male and female scientists in STEMM[5] disciplines. The survey was conducted in 2003, 2004, 2006 and 2010 and the results are used to measure progress towards gender equality in UK higher education institutes. In 2008, the Athena Project was succeeded by the Athena Forum which continues the Athena Project's activities.

The Athena SWAN charter is managed by the Equality Challenge Unit and it supports the career development of women in STEM departments through an award scheme which recognises institutional commitment to gender equality. Both entire institutions and individual departments are eligible to apply for an Athena SWAN award which distinguishes between three levels of gender equality advancement from bronze to gold. Once awarded to an institution or department the award requires renewal. There is evidence that the Athena SWAN award has become a consideration in research funding decisions. In 2011, Chief Medical Officer Professor Dame Sally Davies announced that the National Institute for Health Research would only shortlist medical schools for funding if the school was holding a Silver Athena SWAN Award (Jarboe, 2013).

Examples of positive action initiatives targeted particularly at early career researchers include research grants to postdoctoral researchers that enable women to take maternity leave during their funding period (Whitelegg et al., 2002). The Royal Society offers such fellowships which also allow award-holders to switch between full-time and part-time work, reclaim any time lost during maternity leave and/or part-time work, as well as claiming funds for family support during conferences or work visits abroad (Zalevski et al., 2009). While these developments undoubtedly represent structural changes in favour of gender equality in science in higher education, there have been calls for strengthening support for early career researchers. For example, the experiences of PhD students are not included in the Athena SWAN award criteria.

Conclusion

This working paper has provided an overview of the gendered implications of academic STEM careers in the UK with a focus on the hurdles that female PhD students and postdoctoral researchers experience. While women's numbers have increased particularly at student, PhD and postdoctoral level in SET disciplines, academic careers continue to disadvantage women on a number of different levels. The major structural issues that deter women from pursuing an academic career in science are short-term contracts, long and irregular working hours, the requirement to be internationally mobile and the difficulties of starting a family that follow from these. Further issues relate to masculine-oriented departmental cultures, which cause women to feel more like students than a member of staff, as well as principal investigators who fail to support them in developing an autonomous research profile.

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