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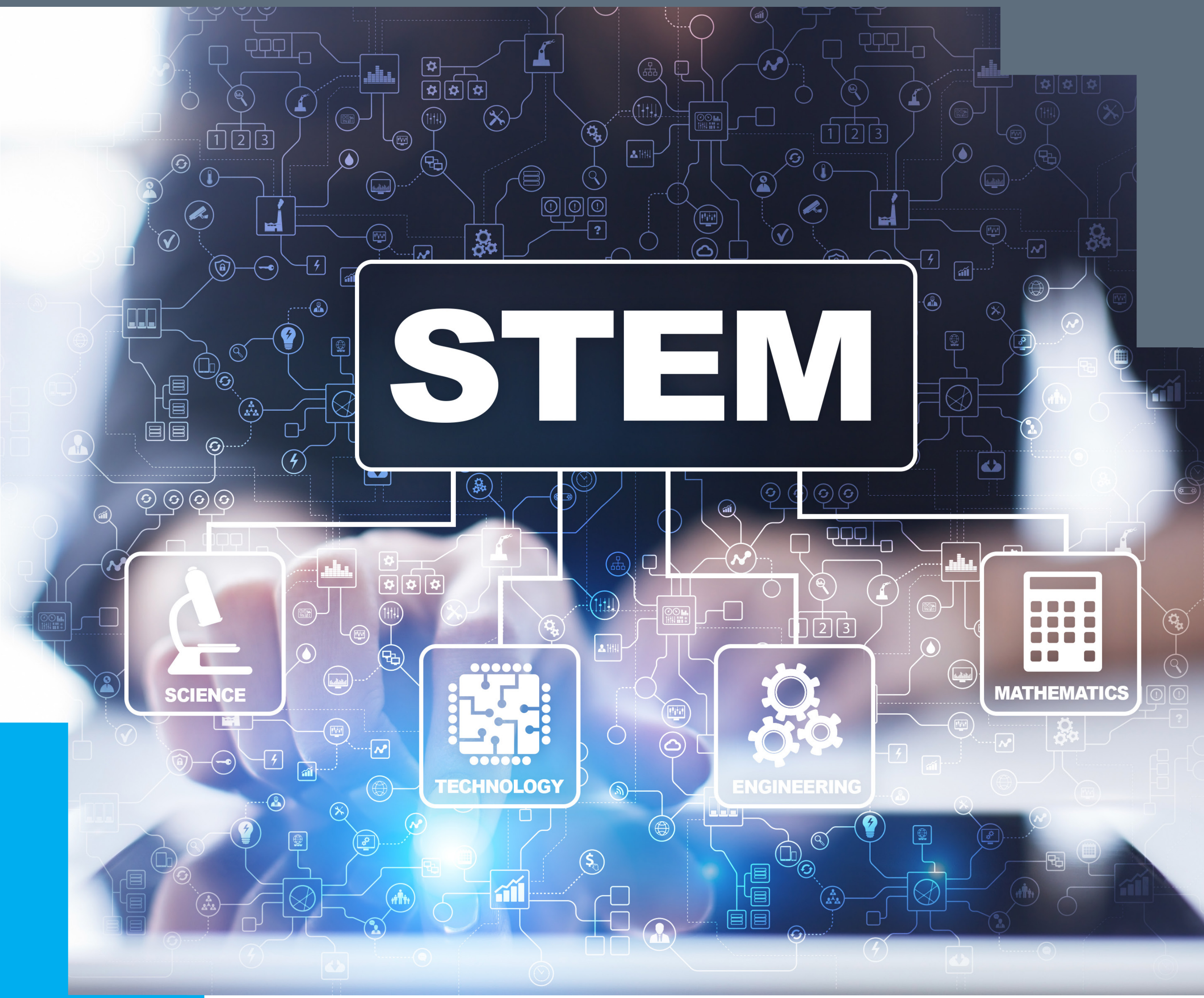
The employment trajectories of Science Technology Engineering and Mathematics graduates

Final report - February 2018

Professor Emma Smith and Dr Patrick White



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Contents

Executive Summary

Introduction

The aim of this study is to contribute to the 'STEM skills deficit' debate by providing much needed evidence on STEM career trajectories in the graduate labour market. The research draws on data from four national data sources: the Higher Education Statistics Agency (HESA) Destination of Leavers from Higher Education survey (DLHE), the Annual Population Survey (APS), the 1958 National Child Development Study (NCDS) and the 1970 Birth Cohort Study (BCS). It also refers to earlier work using UCAS data. It provides detailed empirical evidence on the career paths of STEM graduates from the early 1980s to the current decade. The study addresses the following research questions:

1. What are the destinations of STEM graduates directly after graduation?
2. What are the occupational positions of older STEM graduates, aged 25 to 64?
3. What are the longer-term occupational trajectories of STEM graduates?
4. How do patterns of employment for STEM graduates compare with employment patterns for those with degrees in other subjects and with non-graduates?
5. How closely is participation in STEM careers related to individual characteristics such as sex, ethnicity and educational background?

Summary of main findings

The main findings from the study are outlined below. Further information on the datasets and definitions used in this research appear in Appendices A and B. A fuller discussion of the results is presented later in the report.

What are the destinations of STEM graduates directly after graduation?

Data from the HESA first destination survey from 1994 to 2011 were used to establish patterns in the early career destinations of recent graduates, and to examine variation over time and between subject areas. The key findings were:

- The destinations of STEM graduates have remained remarkably stable over time, regardless of the particular degree subject studied. This is the case despite major changes in higher education policy – such as the introduction of, and subsequent increase in, tuition fees – and changes in the national economy.
- The majority of STEM graduates enter graduate-level employment shortly after graduating. But while levels of unemployment for recent graduates have remained reasonably stable over the past twenty years, they are among the highest for those with computer science (around 13%) and engineering degrees (around 10%) – two of the main subject areas where concern about shortages has been raised.
- Around 50% of employed computing and engineering graduates enter highly skilled (HS) STEM jobs, but a relatively high proportion (18% and 14%, respectively) are employed in routine occupations six months after graduating. This, alongside findings on unemployment rates, suggests two routes for graduates from these disciplines: one that leads to highly-skilled professional jobs and another that leads to routine employment or unemployment.
- A disproportionate number of graduates from higher status universities enter HS STEM roles in the six months following graduation, compared to more recently-established institutions. In some years almost twice the proportion of employed graduates from Russell Group universities found employment in HS STEM roles compared to their peers in University Alliance/ Million+ institutions.
- A larger proportion (around 25%) of graduates from the physical, mathematical and biological sciences remain in education and undertake additional training prior to entering the workforce compared to engineering (12%-16%) and computer science (around 12%) graduates. This may be because their undergraduate degrees do not provide them with the necessary knowledge and skills to enter the HS STEM occupations they are aiming for, or that additional study is required – or perceived to be required – to make them desirable to employers.

What are the occupational situations of older STEM graduates, aged 25 to 64?

Annual Population Survey (APS) data from 2004 to 2010 were analysed in order to establish the occupational positions of older STEM graduates. The key findings were:

- The vast majority (87%) of STEM graduates are employed in graduate-level jobs. However, only just over half that proportion (46%) work in HS STEM positions.
- STEM graduates were employed in many different (often non-STEM) occupational groups but only a minority (about 17%) worked in the key STEM 'shortage' occupational areas as science, ICT or engineering professionals.
- The biological sciences stand out as relatively weak in terms of HS STEM employment outcomes for both recent and more established graduates. Biological science graduates were less likely than those from other key STEM disciplines to be employed in STEM jobs; only 32% were working in these roles compared with 46% of STEM graduates. The proportions entering graduate-level jobs were similar, however: 82%, compared with 87% for all STEM graduates.
- Professional engineering occupations attract relatively few graduates from other disciplinary backgrounds: over 70% of graduates employed in this area have engineering degrees. Similarly, the ICT sector is very reliant on maths and computer science graduates (over two-thirds of graduates in this sector have maths or computer science degrees). This may be because of the specialised nature of these occupational areas but, given that the majority of engineering and ICT professional jobs are filled by non-graduates, it is surprising that there are not more graduates from other STEM backgrounds working in these areas.
- Relatively high proportions of STEM graduates are employed in the teaching profession and this is the most common occupational destination for maths (26%), biology (19%) and physics (17%) graduates. But only a relatively small proportion of STEM graduates work in roles likely to involve substantial amounts of laboratory work. These outcomes do not reflect the curricula of most STEM degrees – particularly in the natural sciences – where there tends to be considerable emphasis on laboratory skills and much less coverage of subject-related pedagogy. This is particularly important given the frequently reported shortages of suitably qualified graduates to teach mathematics and physics in school. It may reflect the influence of STEM employers, through the sector subject bodies, on the content of undergraduate STEM degree programmes in these subject areas.

What are the longer-term occupational trajectories of STEM graduates?

Data from six sweeps of the 1958 National Child Development Study (NCDS) and five sweeps of the 1970 Birth Cohort Study (BCS) were used to examine long-term occupational trajectories. Particular attention was paid to movement in and out of graduate professions and HS STEM occupations.

- The cohort study data show considerable movement out of scientific jobs as workers get older, with no evidence that many STEM graduates enter HS STEM occupations later in their careers. Some workers left the STEM sector altogether but others may have been promoted into management positions that were not classified as HS STEM roles. The route into HS STEM jobs seems predicated on early entry and there seems to be either limited opportunities or little desire to enter STEM occupations later in life.
- Sectors such as education and health appeared to avoid the problem of attrition faced by those areas that are heavily reliant on HS STEM workers. Levels of employment in these areas remained stable as cohort members aged and some areas, such as functional management, increased their share of graduate workers.

How do patterns of employment for STEM graduates compare with employment patterns for those with degrees in other subjects and with non-graduates?

All four datasets were used to determine the extent to which patterns of employment for STEM graduates compared with those with degrees in other subjects and those who did not have degrees. The most important findings were:

- The variation in employment destinations between STEM graduates is, in many respects, greater than the variation between those with STEM and non-STEM degrees. Because of this, simply grouping subjects into STEM and non-STEM is not particularly useful and can hide important differences between subject groups and individual subjects. For example, biological science graduates who found employment six months after graduation were three times less likely to be in HS STEM jobs than employed engineering graduates and only half as likely as employed STEM graduates as a whole. Interestingly, at this early stage of their careers, however, social studies graduates had a similar level of employment in HS STEM positions as those with biological science degrees.
- The destinations of STEM and non-STEM graduates were similar in terms of the status of the occupations they worked in and the most common areas of work. By age 30, similar proportions had graduate jobs and, for the most part, the largest recruiting occupations for both groups were teaching and functional management.

- There is some evidence of a 'slower start' among non-STEM graduates in terms of securing graduate-level jobs. But any longer term advantage of STEM degrees over non-STEM degrees, in terms of the ability to secure and retain graduate-level employment, is minimal. There was certainly no evidence of dramatically better employment outcomes for STEM graduates as a whole.
- The majority of HS STEM positions are held by non-graduates. APS data showed that, overall, 53% of HS STEM positions were held by non-graduates. Even among younger workers aged 25-29, more than one-third (37%) of HS STEM jobs were filled by employees without undergraduate degrees.

How closely is participation in STEM careers related to individual characteristics such as sex, age and educational background?

All four data sets were used to examine inequalities in participation in STEM careers. The findings revealed important issues in two main areas: the participation of women and the employment prospects of graduates from pre-1992 universities.

- Gendered patterns of participation in STEM subject areas and the wider STEM labour market persist. Female STEM graduates were as likely as men to gain employment in graduate jobs (86% of female graduates and 87% of males) but were less likely to secure work in the HS STEM sector (32% and 55% respectively). These patterns are established soon after graduation and persist through to late career. This was a consistent finding in all the datasets used in this analysis. Not only do fewer women study for STEM degrees in the first place, a smaller proportion of female than male STEM graduates also go on to work in the sector.
- Inequalities in career trajectories were greatest for female graduates from male dominated subject disciplines, particularly engineering and computer science. This is important given the shortage discourses surrounding those two subject areas.
- There are clear differences in the early career destinations of STEM graduates from different types of institution. Graduates from the former polytechnics have poorer early career opportunities than those graduating from more research-intensive institutions, particularly in terms of HS STEM roles. This is particularly evident for computing, engineering and technology graduates. These inequalities in participation in HS STEM jobs are surprising given the long history of the polytechnics in providing advanced vocational training for the industrial sector. They are also important in the light of calls to increase the number of young people studying for science degrees.

Summary of the implications of the main findings

There are several key findings to emerge from this study. Each finding, along with some of its most important implications, is listed below. A more comprehensive list of implications can be found at the end of the report.

Finding 1:
Only a minority of STEM graduates enter HS STEM occupations, even in shortage areas

As employers recruit only a minority of STEM graduates for HS STEM roles, there are large numbers of STEM graduates that could potentially work in HS STEM roles, many with degrees in 'shortage' areas or related disciplines.

Simply increasing the number of students in the 'STEM pipeline' is unlikely to be an efficient way of providing employers with the graduate employees they want. This is particularly the case in some STEM subjects, such as the biological sciences, that provide a very small proportion of the HS STEM workforce. education and undertake additional training prior to entering the workforce compared to engineering (12%-16%) and computer science (around 12%) graduates. This may be because their undergraduate degrees do not provide them with the necessary knowledge and skills to enter the highly skilled STEM occupations they are aiming for, or that additional study is required – or perceived to be required – to make them desirable to employers.

Finding 2:
The three key STEM shortage occupations (science, engineering and ICT professionals) attract only a minority of STEM graduates. The highest recruiting occupational groups are teaching and functional management.

STEM graduates are either being attracted to other occupations areas or failing to find work in HS STEM roles. The majority are not going into highly paid sectors such as banking and finance but into areas such as education and into lower-level management positions. Employment in STEM shortage areas is either unattractive or unobtainable for the majority of STEM graduates.

Even though teaching is the most common occupational destination for STEM graduates, many degrees cover little in the way of subject-based pedagogy. This is particular important given that the recruitment of science teachers has traditionally been difficult.

Finding 3:
A substantial proportion of STEM graduates move out of HS STEM roles as their careers progress but few older workers move into HS STEM positions.

Retaining current workers in HS STEM positions could help reduce the number of vacancies to be filled by recent graduates.

Attracting older STEM graduates into the sector for the first time may help fill current vacancies. Non-STEM graduates and non-graduates – of any age – could also be sources of new recruits.

Finding 4:
The majority of HS STEM workers are non-graduates.

STEM degrees, or graduate-level education in any subject area, are not a pre-requisite for employment in all HS STEM jobs, even if they are considered desirable.

The emphasis on participation in higher education in recent decades may be over-shadowing other routes into HS STEM jobs such as apprenticeships.

Finding 5:
There are large differences in the proportion of different groups of STEM graduates entering HS STEM jobs. Much smaller proportions of graduates in some STEM subjects, from some types of university, and from different social groups, enter HS STEM occupations than others.

Particular groups of STEM graduates, in particular biological science graduates and those graduating from post-1992 institutions, are currently under-represented in the HS STEM workforce and could be a valuable source of potential employees if targeted effectively.

The differential participation in HS STEM careers of graduates from post-1992 institutions is striking and may reflect a gap between the skills and knowledge of the students graduating from these institutions and the requirements or expectations of employers.

Finding 6:
There is little variation between the immediate and longer-term occupational destinations of STEM and non-STEM graduates in terms of graduate-level employment.

The vast majority of graduates are employed in graduate-level positions by the end of their twenties. STEM employers are competing for workers in a context in which most graduates are able to find high status, professional-level work. The salaries and working conditions they offer must reflect this if they are to remain competitive.

Encouraging students to study STEM degrees on the basis of better labour market outcomes is ethically questionable. STEM graduates have little advantage over non-STEM graduates in terms of securing graduate-level employment and most STEM graduates never work in HS STEM jobs.

Conclusion

For this project we analysed four high quality data sources to examine the careers of STEM graduates. Although STEM graduates were our main focus, for comparative purposes we also analysed data on non-STEM graduates and non-graduates. We examined occupational destinations shortly after graduation, longer-term career trajectories and historical trends in the STEM labour market. Although the demand for STEM workers has not been measured directly – through an examination of unfilled posts for example – we have occasionally used patterns in the STEM labour market and the trajectories of STEM graduates and workers to make inferences about demand. The consistency of the results from our analyses of the four different data sets suggests that the findings are robust. The most important conclusions are outlined directly below.

There is no evidence of a shortage of STEM graduates *per se*. Only a minority of STEM graduates ever work in HS STEM occupations, and an even smaller proportion are employed in key 'shortage' areas. Any mismatch between the supply and demand for STEM workers cannot, therefore, be attributed to the number of students graduating with STEM degrees. Problems with the 'supply' of STEM workers are more likely to be explained by the willingness of graduates to pursue careers in STEM fields and the recruitment practices of employers.

There are large differences between STEM subjects in terms of the proportion of graduates that go on to work in STEM fields, particularly in highly skilled positions. Engineering does well in this regard, while in some subject areas – such as biological sciences – smaller proportions of graduates go on to work in HS STEM positions than in some non-STEM subjects.

There is also a stark contrast between the employment trajectories of graduates from 'elite' universities and those from some of the newer, post-1992 institutions.

Executive Summary

The graduate STEM workforce is currently disproportionately recruited from traditional-age male students graduating from high status institutions, with certain subject specialisms.

There is attrition from STEM occupations over the course of individuals' careers that is not seen in other fields. A larger proportion of STEM workers move out of highly skilled positions later in their careers. Unlike in other professions, such as education or health, this is not balanced by an intake of more mature recruits; graduates are unlikely to enter STEM positions if they do not do so shortly after graduation.

Most highly skilled STEM workers are non-graduates. Any increase over time in the proportion of STEM workers with degrees appears to only reflect the historical increase in participation in higher education. Focusing too much attention on graduates ignores the source of the majority of the STEM workforce.

Background to the study

Scientific progress is one essential key to our security as a nation, to our better health, to more jobs, to a higher standard of living, and to our cultural progress.
(Vannevar Bush, 1945:6)[1]

Science is more essential for our prosperity, our security, our health, our environment, and our quality of life than it has ever been.
(President Barack Obama, Speech to the National Academy of Sciences, 2009)[2]

Media accounts frequently report problems with the supply of highly skilled (HS) workers in the areas of science, technology, engineering and mathematics (STEM).[3] These reports echo the concerns expressed by both industry and governmental bodies, that the supply of STEM graduates is crucial to the current and future economic prosperity of the nation but that employers are currently unable to recruit a sufficient number of workers with the right skills.[4] A shortage of adequately skilled STEM workers, it is argued, is holding back economic growth and placing UK industry at a disadvantage in relation to international competitor countries.[5] Numerous corporate and governmental bodies have examined the supply of the STEM workforce and have found it wanting in terms of both quantity and quality.

As a consequence, policymakers have responded to calls from industry, government and universities to enact policies and initiatives – often requiring the investment of considerable amounts of public funds – that are aimed at remedying the situation.

These accounts have not gone unchallenged, however. Other commentators have argued that the supply of STEM workers is more than enough to meet demand and that the picture is much healthier than is often suggested. Rather than there being a shortage of STEM professionals, they claim that many highly qualified STEM graduates struggle to find appropriate employment and instead find work in non-STEM fields, are ‘underemployed’ in STEM occupations that do not require their full range of skills and knowledge, or are unemployed.[7]

Whether a sufficient number of highly qualified STEM workers are being educated and trained in the UK, and elsewhere, is an important question. The answer has implications not only for educators, employers and policy makers but also individuals who are currently engaged in – or are considering entering – education or training in this area. At the time this study was commissioned, however, there was insufficient evidence to resolve this debate. In order to do so it is necessary to determine whether shortages actually exist, the extent of any shortages, and exactly what skills – if any – are in short supply.[8]

The research questions and data sets

The research questions and the data sets used to address them are summarised directly below:

Research Question	Datasets used in the analysis
What are the destinations of STEM graduates shortly after graduation?	Higher Educational Statistical Agency Destination of Leavers from Higher Education 1994-2010
What are the occupational positions of STEM graduates in the labour market as a whole?	Annual Population Survey 2004, 2006, 2008 and 2010
What are the long-term occupational trajectories of STEM graduates?	1970 Birth Cohort Study: 1996, 2000, 2004, 2008, 2012 1958 National Child Development Study: 1981, 1991, 2000, 2004, 2008, 2012.
How do patterns of employment for STEM graduates compare with employment patterns for those with degrees in other subjects?	Higher Educational Statistical Agency Destination of Leavers from Higher Education 1994-2010 Annual Population Survey 2004, 2006, 2008 and 2010 1970 Birth Cohort Study: 1996, 2000, 2004, 2008, 2012 1958 National Child Development Study: 1981, 1991, 2000, 2004, 2008, 2012
How closely is participation in STEM careers related to individual characteristics such as sex, age and educational background?	Higher Educational Statistical Agency Destination of Leavers from Higher Education 1994-2010 Annual Population Survey 2004, 2006, 2008 and 2010 1970 Birth Cohort Study: 1996, 2000, 2004, 2008, 2012 1958 National Child Development Study: 1981, 1991, 2000, 2004, 2008, 2012

Background to the study

The challenges of researching the field

Understanding the relationship between supply and demand in the STEM sector is not straightforward and the complexity of the phenomenon has been a central feature of research and rhetoric in the area for many decades. This study has sought to understand, using the best data available, the broad patterns in participation in STEM sector occupations over the long term. As with any investigation of this type we are limited by the quality and scope of the data available to us. For example, although providing the best available data on individual career trajectories, the cohort studies are limited by having relatively small samples. When the data are disaggregated by both degree subject and occupational role the resulting sub-groups can be very small, meaning that the types of analysis possible are limited. Accounting for patterns and trends in the data is also difficult, and we have offered the most parsimonious explanation for our findings unless there is a compelling reason for a more complicated account.

Nevertheless, despite these limitations, this study represents the most comprehensive analysis of the career trajectories of UK STEM graduates to date. The consistency of the patterns both within and between the different datasets gives us confidence in our findings. We believe that this study has made an important contribution to the research on the supply of STEM workers.

What is meant by a shortage and how can we measure shortages?

The empirical basis for shortage accounts is further complicated by technical and conceptual difficulties in assessing skills supply and demand. A fuller discussion of the long-term policy context surrounding this debate is provided in Smith (2017).

Differences in both the definitions of shortages and the way any 'shortages' have been measured have contributed to the persistence of a debate that has continued for at least 70 years. Discussions in this area have also been characterised by poor data and have been complicated by the existence of clear vested interests from some parties.[9]

In trying to understand whether there is a shortfall of STEM skills we have attempted to identify patterns that might be expected to exist in the data if a crisis account was accurate:

i. Increased levels of participation in higher education STEM programmes as universities respond to the calls from industry to recruit (and train) more students

ii. High proportions of STEM graduates entering highly skilled STEM jobs (especially in 'shortage' areas) upon graduation

iii. High levels of recruitment to, and little attrition from, shortage occupations

iv. Favourable career trajectories for most (traditional) STEM graduates regardless of subject studied or higher education institution attended

v. More favourable occupational trajectories for STEM graduates compared to non-STEM graduates, particularly those with degrees in 'shortage' subjects

vi. Shortage occupations recruiting from a broad range of graduates, and little in the way of differential participation from different social and educational groups

In the concluding section of this report we return to review these patterns in light of the findings from this study.

Detailed findings

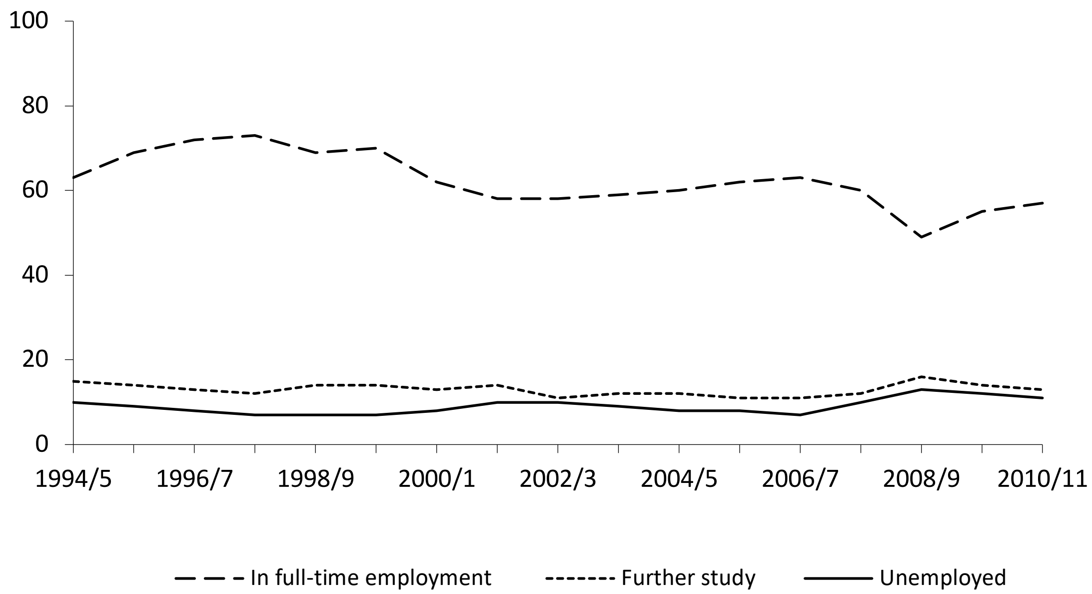
This section provides a more detailed account of the main findings. It is structured around the research questions set out earlier. Further information on the definitions and datasets used in the project are provided in Appendices A and B.

1. What are the destinations of STEM graduates directly after graduation?

1.1 Employment, unemployment and further study

Patterns of early graduate destinations have remained relatively stable between 1994/5 and 2010/11, despite the number of students entering university almost doubling and dramatic changes in the economy. Graduates from the engineering and computer sciences were more likely to enter employment upon finishing university compared to those from the other STEM groups considered in this study, but did not have substantially higher employment rates than graduates as a whole. It is also the case that relatively high proportions of engineering and computer science graduates (in some years more than 10%) were unemployed six months after graduation (Figure 1).

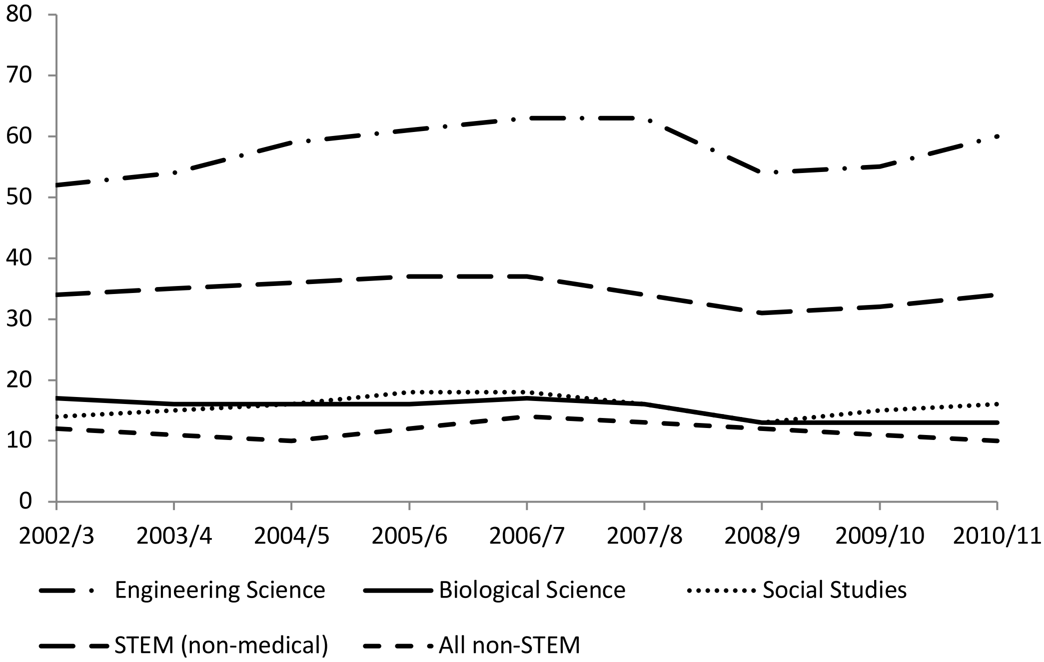
Figure 1: First destinations of engineering science graduates, HESA First Destination Survey Data, 1994/5 to 2010/11



A key focus of the STEM shortage debate has been the lack of highly qualified graduates entering HS STEM jobs.[1] But only around one-third of non-medical STEM graduates (i.e. excluding those who studied medicine and dentistry) who entered employment were working in HS STEM positions six months after graduation, while the figure for non-STEM graduates was around 12% (Figure 2). It is not just the case that only a minority of STEM graduates who find work soon after graduating are employed in HS STEM positions but also that a substantial proportion of non-STEM graduates find similar jobs.

[1] See Appendix 2 for definitions of HS STEM jobs and SOC categories that were adopted in this study

Figure 2: Proportion of graduates gaining employment and entering HS STEM occupations, by subject group, HESA First Destination Survey Data, 2002 to 2010



It is also the case that relatively high proportions (often around a quarter) of graduates from the biological, mathematical and physical sciences remained in education following completion of their first degree. This could be because, for many students in some subject areas, three years of undergraduate study was insufficient to gain employment in their chosen fields, or at least was perceived to be insufficient.

1.2 Variation in destinations by STEM subject group

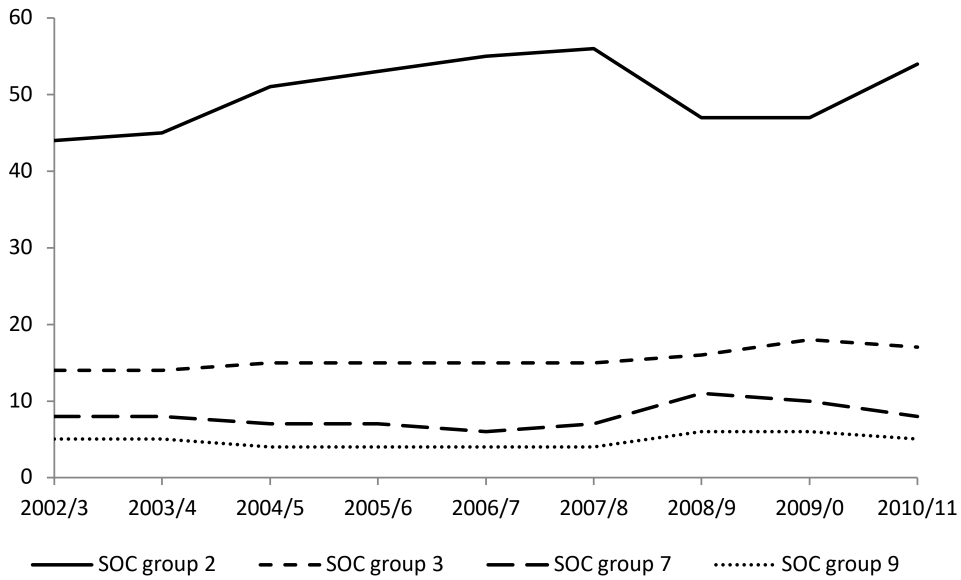
There is considerable variation in the extent to which different STEM subjects supply the HS STEM graduate workforce. For example, between 55% and 60% of engineering science graduates who entered employment were working in HS STEM jobs six months after graduating but for biological science graduates the proportion was around 16%. This is only slightly higher than the proportion of graduates from non-STEM subjects and in some years was actually lower than the proportion of social studies graduates working in HS STEM positions.

It is unsurprising that STEM graduates as a whole find it easier to obtain HS STEM occupations than their counterparts with non-STEM degrees. What is more remarkable is the similarity in the proportion of non-STEM graduates entering these kinds of occupations when compared with graduates from some STEM subject groups, such as the biological sciences. Further comparison with the career trajectories of non-STEM graduates is provided below.

1.3 Variation in occupational destinations by STEM subject group

The four most common occupational group destinations (SOC2, SOC3, SOC4 and SOC7) for non-medical STEM graduates are the same as for graduates in general, suggesting that, in terms of status, the type of jobs that non-medical STEM graduates take are similar to other employed graduates.

Figure 3: Largest four occupational groups for engineering science graduates entering employment, HESA First Destination Survey Data, 2002/03 to 2010/11.



Among engineering graduates, the majority of those who found employment entered SOC2 occupations (e.g. around 54% from the 2010/11 cohort). This is among the highest rate of entry into SOC2 jobs for non-medical STEM graduates; the figure for biological science graduates was only 13%. Engineering science graduates have better chances than most other non-medical graduates of obtaining high status professional positions shortly after graduation, and engineering stands out as the non-medical STEM subject group offering the best prospects for immediate entry into higher-level professional careers (Figure 3).

However, at the 'lower' end of the occupational scale (i.e. occupational groups SOC 7 and 9) the proportion of engineering science graduates is very close to that of the general graduate population, and there are also relatively high unemployment rates among graduates with engineering degrees.

These findings point to different types of destinations for different groups of engineering graduates, with just over a quarter working full-time in high status SOC1 or SOC2 occupations, another quarter going into lower status full-time jobs (some of which require degrees), and the remaining half continuing their studies, working part-time, registering as unemployed or engaged in other activities.

So while engineering graduates have a considerable advantage over most of their peers in terms of both gaining employment and being employed in high status and graduate positions, only a minority find themselves in professional careers six months after graduating, and more than one in ten are unemployed. These figures have been relatively stable for some time and fit uncomfortably with 'crisis' accounts of chronic shortages of STEM – and particular engineering – graduates.

2. What are patterns of employment among older STEM graduates (aged 25 to 64)?

2.1 Occupational destinations of STEM graduates

The Annual Population Survey (APS) includes detailed information on the occupational status of STEM graduates in the labour market. The data provide a cross-sectional snapshot of the labour market on a very large scale. These data provide information on occupational destinations of adults aged 25 to 64 years, complementing the HESA data that showed destinations six months after graduation. APS data from 2004, 2006, 2008 and 2010 were included in the analysis. As initial analyses revealed no substantial differences between these four years, the findings presented in this report are for a combined data set of 803,634 cases.

Table 1: SOC 2000 occupational sectors for STEM graduates aged 25 to 64, APS data 2004, 2006, 2008 and 2010 (combined)

	All STEM		Eng. Sci		Math/Comp Sci		Bio. Sci.		Phys. Sci.	
	N	%	N	%	N	%	N	%	N	%
Graduate job	39448	87	7229	86	6288	85	5531	82	5610	85
HS STEM job	21068	46	5148	61	3418	46	2168	32	2673	41
Production managers (112)	2250	5	1182	14	124	2	95	1	272	4
Functional managers (113)	3865	8	877	10	1138	15	560	8	773	12
Science professionals (211)	1695	4	43	0.5	24	0.3	702	10	642	10
Engineering profs (212)	2957	6	2330	28	101	1	42	0.6	281	4
ICT professionals (213)	3133	7	588	7	1944	26	116	2	359	5
Health professionals (221)	4796	10	20	0.2	11	0.1	450	7	91	1
Teaching profs (231)	4145	9	332	4	1054	14	1076	16	1012	15
Bus. Stats profs (242)	1054	2	162	2	447	6	120	2	209	3
Arch, planners. etc. (243)	1592	3	158	2	14	0.2	9	0.1	52	1
Eng. & Sci. tech (311)	702	1	167	2	54	1	161	2	177	3
IT service delivery (313)	655	1	99	1	359	5	51	1	94	1
Ass. Health profs (321)	3090	7	17	0.2	18	0.2	174	3	48	1

Shaded rows highlight ‘shortage’ subject areas.

Table 1 shows the proportion of STEM graduates working in graduate-level and highly skilled (HS) STEM jobs. The table also shows the most common occupational group positions for all employed STEM graduates aged 25 to 64. The 12 occupational groups included in the table were the largest ‘recruiters’ of STEM graduates and, combined, make up over 60% of the employment destinations of working respondents with STEM degrees.

In relation to ‘shortage’ accounts, the most important finding from the analysis of APS data is that only 17% of employed STEM graduates held positions in the three occupational groups that tend to be the focus of STEM shortage concerns: 4% were science professionals (SOC211), 6% worked as engineering professionals (SOC212) and 7% held positions as ICT professionals (SOC213).

If there are genuine shortages in these areas, it must be the case that the remaining 83% of STEM graduates either do not wish to work in science, engineering or ICT, find other occupational areas more attractive, or are considered unsuitable by employers. This evidence does not point to a shortage in STEM graduates *per se* but instead either a shortage of those motivated to work in shortage areas or a mismatch between the skills, knowledge and qualifications of many graduates and the demands of employers. Either way, when only a small minority of STEM graduates work in these areas, simply increasing the number of students studying for STEM degrees is unlikely to be a very effective way of addressing this issue.

As with the early career destination data shown above, there are important differences in the career destinations of engineering and biological science graduates. Nearly double the proportion of engineering graduates (61%) than biological science graduates (32%) were employed in HS STEM jobs. One factor contributing to this difference is the relatively high proportion of biological science graduates working in teaching related jobs that, on the criteria adopted for this study, were not categorised as HS STEM jobs. The APS data show that 16% of biological science graduates worked in the 'teaching professionals' occupational group (SOC231) compared to only 4% of engineering science graduates. Teaching was the most common occupational destination for biological and physical science graduates (at 15%), and was particularly common among physics, biology and mathematics graduates.

2.2 Subject differences in employment in 'shortage' areas

Table 1, above, shows that while relatively large proportions of STEM graduates with degrees in 'shortage area' subjects worked in the occupational sector directly associated with their degree (such as engineering, for engineering science graduates) much smaller proportions worked in 'allied' occupational areas.

ICT professional positions (SOC213) were the most popular occupational destinations for employed mathematics and computer science graduates, with 26% finding work in this area. But only 2% of biological science graduates, 5% of physical science graduates and 7% of engineering sciences graduates were employed as ICT professionals.

A similar picture can been seen for engineering professional occupations (SOC212). Again, more than a quarter (28%) of engineering science graduates were employed in this area, compared to only 4% of those with physical science degrees, 1% of maths and computer science graduates and only 0.6% of biological sciences graduates. Professional science occupations (SOC211) accounted for the destinations of 10% of employed biological science graduates and 10% of physical science graduates but relatively few engineering sciences (0.5%) or maths and computer sciences (0.3%) graduates.

It is perhaps unsurprising that graduates are more likely to enter occupational areas that are directly relevant to their subject knowledge. Engineering graduates might be expected to be more attracted, and often better suited, to professional engineering roles, than their peers who hold degrees in other STEM subjects. Similarly, it is understandable that those with maths and computer science degrees are more likely to work in ICT than in other occupational areas.

However, given that 'shortage' accounts have persisted for many decades, and considering that employers have complained about their inability to fill posts in these occupational areas, it is surprising how few graduates from allied STEM backgrounds are employed in these shortage areas. This suggests either that these shortage occupational destinations are unattractive to many STEM graduates or that these careers are effectively closed off to them by the recruitment practices of employers.

Table 2 shows the subject specialisms of graduates working in key occupations. Whereas the data in Table 1 showed what proportion of employed graduates worked in particular occupational areas, these data shows the distribution of degree subjects among graduate workers in particular occupations. This shows how reliant each occupational area is on graduates with degrees in particular subjects.

The engineering sector stands out as particularly reliant on engineering graduates, with 73% of graduates working as engineering professionals (SOC 212) having degrees in engineering. Those with degrees in the biological and physical sciences made up the majority of graduates working as science professionals (SOC 211), accounting for over three-quarters of the graduate workforce in this occupational group.

However, half of the graduates working in ICT professional positions (SOC213) had degrees in subjects other than mathematics or computing. Fifteen percent of graduates had degrees in engineering, for example. Although those with degrees in engineering, maths and computing make up nearly two-thirds of the graduate workforce in ICT, this sector does recruit graduates from a wider range of subject backgrounds than the engineering or science sectors.

The analyses presented in this section have shown two, related patterns. Firstly, students who graduated with STEM degrees in 'shortage' areas are disproportionately likely to enter the occupational area directly associated with their degree (e.g. engineering graduates finding employment as professional engineers). This is, in many ways, unsurprising and would be expected in a context of labour shortages in that sector. However, what is more interesting, and what might not be expected when such shortages exist, is the relatively small proportion of STEM graduates from 'allied' disciplines working in these 'shortage' areas. Only very small proportions of graduates with maths, computer science or physical science degrees work as engineering professionals, for example. Similarly professional science positions attract relatively few students with degrees outside the biological and physical sciences.

Detailed findings

Table 2: Subject specialisms of graduates working in HS STEM and selected higher recruiting SOC 2000 occupations, percentages, APS data 2004, 2006, 2008 and 2010 (combined)

%	N	Bio Sci.	Phys. Sci	Math/ Comp Sci	Eng.Sci	Social Studies	Bus Admin	Other Subject
Production Man. (112)	3284	3	9	4	37	4	16	27
Functional Man. (113)	10386	6	8	11	9	9	31	26
Man. Farm (121)	190	13	18	2	11	4	7	45
Science Profs (211)	1854	40	36	1	2	1	1	19
Eng. Profs (212)	3367	1	9	3	73	1	4	9
ICT Profs (213)	4083	3	9	50	15	3	8	12
Health Profs (221)	5301	9	2	0.2	0.4	1	0.5	87
Teach. Profs (231)	19426	6	5	6	2	6	4	71
Research Profs (232)	1013	19	14	9	4	14	5	35
Legal Profs (241)	2538	1	1	1	1	9	2	85
Bus/stats. Profs (242)	3927	3	6	12	4	13	48	14
Architects (243)	1938	1	3	1	8	4	7	76
Sci/Eng. Techs (311)	929	19	20	6	19	3	4	29
Draughtspersons (312)	292	2	6	4	20	2	2	64
IT Occupations (313)	980	5	10	39	10	5	10	21
Transport A/Prof (351)	218	7	12	7	39	6	11	18
Bus/Finance A/Prof (353)	2602	5	7	9	7	15	30	27
Conservatn. A/Prof (355)	390	17	32	1	8	4	4	34
All HS STEM	30367	8	9	12	18	5	13	35
All jobs	119467	6	6	7	7	9	13	52

3. What are the career trajectories of STEM graduates?

Data from the two cohort studies were used to track the career trajectories of STEM graduates from age 26 to 42. As there was remarkable similarity in the findings from the BCS70 and the NCDS, we have focused on the findings for the BCS70 here. Unlike the HESA and APS data used for the research presented above, the cohort studies are longitudinal and allowed the tracking of career trajectories of individual respondents. Because of the longitudinal nature of the study, the number of cases in the cohort studies were much smaller than the APS or HESA data sets. However, our comparisons with the other data sets suggested that the cohort studies were broadly representative of the wider population.

3.1 STEM graduates working in graduate jobs

The vast majority (83%) of employed STEM graduates were working in a graduate job by the age of 26, a figure that rose at age 30 and again at age 34 (Table 3). This shows that there is some movement into graduate jobs, even for those who have not entered graduate-level positions some years after finishing their degree.

However, the proportion of STEM graduates working as scientific or engineering professionals was consistently low across all study sweeps. At no point between the ages of 26 and 42 were more than 11% of STEM graduates working in these two key 'shortage' areas of the labour market (SOC211, SOC212) and by age 42 only 7% were employed in these two occupational groups. A larger proportion of STEM graduates entered professional ICT roles, but this peaked at 12% at age 30 before falling at each sweep to only 7% by age 42.

Employment patterns in other occupational groups show different patterns. The proportion of STEM graduates working as functional managers (SOC113) rose from only 6% at age 26 to 13% at age 42 – nearly the same proportion as those working in science, engineering and ICT roles combined. This may be an inevitable consequence of promotion from technical to managerial positions for those working in the STEM sector. However, the two other common destinations for STEM graduates – health and teaching – do not suffer from the same pattern of attrition. There is no evidence of a systematic decline in the proportion of STEM graduates working in these professions; the figures are relatively stable and are actually at their highest at age 42, when those for the 'shortage' areas are at their lowest.

So although STEM graduates continue to move into graduate employment over the course of their careers, there is no evidence of substantial movement into 'shortage' STEM areas; it is actually the case that there is some movement out of such positions. This may be explained by promotion into managerial roles but this does not appear to be a problem in the teaching and health sectors and may be an issue that predominantly affects the STEM labour market.

Detailed findings

Table 3: Employed BCS70 cohort members with STEM degrees in graduate jobs and the highest recruiting SOC 2000 occupational groups, ages 26 to 42

	Age 26		Age 30		Age 34		Age 38		Age 42	
All STEM graduates	N	%	N	%	N	%	N	%	N	%
Graduate job	590	83	636	87	551	91	543	90	565	88
Highest recruiting SOC 2000 Occupational Groups										
Functional managers (113)	34	6	49	8	73	13	75	14	74	13
Science professionals (211)	25	4	27	4	25	5	16	3	16	3
Engineering profs (212)	43	7	36	6	32	6	23	4	22	4
ICT professionals (213)	62	10	77	12	60	11	41	8	40	7
Health professionals (221)	59	10	50	8	47	8	50	9	60	11
Teaching profs (231)	62	10	58	9	52	9	56	10	66	12
Engineering graduates	N	%	N	%	N	%	N	%	N	%
Graduate job	112	85	121	82	108	87	101	85	101	87
Highest recruiting SOC 2000 Occupational Groups										
Production manag. (112)	14	12	13	11	10	9	21	21	15	15
Functional manag. (113)	7	6	9	7	17	16	10	10	8	8
Engineering profs (212)	35	31	28	23	24	22	19	19	17	17
ICT professionals (213)	13	12	24	20	16	15	10	10	14	14
Physical science graduates	N	%	N	%	N	%	N	%	N	%
Graduate job	127	77	151	85	124	91	126	86	137	84
Highest recruiting SOC 2000 Occupational Groups										
Functional manag. (113)	12	9	11	7	11	9	17	13	20	15
Science profs (211)	14	11	18	12	13	10	9	7	10	7
ICT professionals (213)	6	5	12	8	11	9	7	6	4	3
Teaching profs (231)	18	14	22	15	22	18	19	15	20	15
Biological Sci. graduates	N	%	N	%	N	%	N	%	N	%
Graduate job	82	83	89	85	76	87	81	95	84	89
Highest recruiting SOC 2000 Occupational Groups										
Functional manag. (113)	3	4	5	6	9	12	13	16	11	13
Science profs (211)	8	10	6	8	6	8	5	6	4	5
Teaching profs (231)	18	22	16	18	15	20	18	22	23	27

A minority of engineering science graduates were employed in engineering professional occupations (SOC 212) at each of the age points surveyed. Less than one-third (31%) worked in this kind of occupation at age 24 and the numbers fell at each subsequent sweep. The next most popular occupational destination for engineering graduates was in professional ICT roles but no more than 16% were employed in these roles at any sweep. It is possible that some of this movement out of SOC2 (professional) jobs – and engineering professional roles in particular – was into SOC1 (managerial) roles, but the small numbers in these subgroups make it difficult to establish this with any confidence.

The trajectories of physical science graduates show the same patterns of attrition from 'shortage' areas over the course of their careers. While 12% worked as science professionals at age 30, this had declined to 7% by age 38. Another 8% were employed as ICT professionals at age 30 but this had fallen to 3% by age 42. The most common occupational destination for physical science graduates, however, was teaching. At every BCS70 sweep from age 26 to 38, a larger proportion of physical science graduates worked in this occupational group than any other. Only at age 42 was this matched by employment in any other occupational group, in this case functional management.

Even larger proportions of biological science graduates worked as teaching professionals. This varied between a low of 18% at age 30 to a high of 27% at age 42. This is in stark contrast to the proportion working as professional scientists, which fell over time from 10% at age 24 to only 5% at age 42. By age 42, more than five times the number of biological science graduates worked as teachers than science professionals. As was the case for engineering science and physical science graduates, functional management was also an important destination. The proportion of biological science graduates in this occupational group increased from 4% at age 26 to 13% at age 42.

3.2 Graduates working in highly skilled STEM jobs

Examining destinations in terms of the broader category of HS STEM jobs shows a similar picture in terms of both change over time and differences between subject areas. BCS70 data shows that the proportion of employed STEM graduates holding HS STEM jobs declined as cohort members aged, from 50% at age 26 to 40% by age 42. Engineering graduates had the highest rate of HS STEM employment, with 69% of those in work being employed in these positions at age 26, but falling to 56% by age 42. Biological science graduates had the lowest levels of HS STEM employment. Only 33% of those in employment at age 26 were in HS STEM jobs and by age 42 this had dropped to 25%.

The patterns of employment in HS STEM work are different to the patterns for graduate-level positions. Unsurprisingly, levels of graduate employment for STEM graduates are much higher than the proportion working in HS STEM jobs. However, while rates of graduate employment increase as cohort members age, the proportion in HS STEM positions declines. STEM graduates who moved out of HS STEM roles tended to remain in graduate-level work and, given the increase in the proportion of those working in management positions shown earlier, one plausible explanation for this pattern is that HS STEM workers being promoted into management roles that fall outside the definition of HS STEM jobs. This is not a trend that is seen in other areas that employ large number of both STEM and non-STEM graduates – such as teaching or health – and may reflect the particular occupational structure of the STEM sector. However, it is an important feature of the STEM labour market that must be considered when assessing the demand for STEM workers.

Detailed findings

Table 4: Employed BCS70 graduates in highly skilled STEM jobs by subject group, ages 26 to 42

	Age 26		Age 30		Age 34		Age 38		Age 42	
	N	%	N	%	N	%	N	%	N	%
All cohort members	6903	13	9096	15	7989	16	7492	16	8298	15
All graduates	1382	32	1337	33	1179	34	1156	31	1220	28
Non-graduates	5521	8	7759	12	6810	13	6336	14	7078	12
STEM graduates	597	50	984	49	900	48	871	44	944	40
Biological sciences	82	33	89	33	76	32	81	23	84	25
Physical sciences	127	42	151	50	124	47	126	40	137	40
Maths/computing	111	50	111	52	98	49	94	45	99	36
Engineering	112	69	121	63	108	62	101	60	101	56
Non-STEM graduates	604	12	1077	13	950	14	925	14	1037	13
Social Sciences	98	15	110	22	93	25	98	17	95	16
Business/admin.	138	25	151	26	127	31	127	25	129	21
Languages	128	8	126	14	102	9	95	18	110	11

The proportion of graduates with non-STEM degrees working in HS STEM jobs is also interesting. This figure varied between 12% and 14% but remained relatively stable as cohort members aged. Unlike with STEM graduates, there was no evidence of substantial decline in this proportion over time. Although, as would be expected, this proportion is much smaller than for those with STEM degrees, in absolute terms slightly more non-STEM than STEM graduates were employed in HS STEM positions at every survey sweep.

Particular groups of non-STEM graduates, such as those with degrees in business and administration, had relatively high levels of participation in HS STEM occupations. Between 21% and 31% of business and administration graduates held HS STEM jobs at different survey sweeps. At certain points, larger proportions of business and administration graduates than biological science graduates worked in HS STEM positions. At age 34, for example, 32% of employed biological science graduates worked in these roles compared to 31% of employed business and administration graduates. By age 38, a larger proportion (25%) of working business and administration graduates were in HS STEM employment than biological science graduates (23%). In terms of absolute numbers, however, more business and administration than biological sciences graduates worked in HS STEM roles at every survey sweep. APS data showed that, for a much larger sample, nearly twice as many (n=4212) business and administration graduates worked in these positions as did biological science graduates (n=2293).

Employment in HS STEM positions was not uncommon for social science graduates, with between 12% and 14% working in these roles at different age points. Because of the relatively large number of students with social science degrees, those working in HS STEM positions also outnumbered HS STEM workers with biological science degrees at every age point in the survey.

Analysis of NCDS data revealed very similar findings to those from the BCS70, presented here, suggesting that these patterns spanned more than one generation.

Although the number of cases in some of the analyses presented here are relatively small, the consistency of the patterns observed, and the supporting evidence from the HESA and APS data, suggest that the following conclusions can be confidently drawn. Although the vast majority of STEM graduates gain graduate employment, and this proportion continues to grow as cohort members age, only a minority find work in STEM 'shortage' areas or HS STEM jobs at any point in their careers. The proportion in both 'shortage' areas, and HS STEM jobs in general, diminishes as they get older, perhaps partly because of promotion from technical to managerial roles. Employment as either an education, health or management professional is as common among STEM graduates as is working in ICT and considerably more likely than being employed as an engineering or science professional. Importantly, employment in these others areas did not decline as cohort members progressed through their careers, suggesting that problems of attrition may be worse in, or particular to, STEM occupations.

There is also little evidence that STEM graduates enter HS STEM occupations later in their lives. One reason for this might be that rapid technological changes in the field mean that STEM degrees have a short 'shelf life' and the knowledge and skills that are developed become quickly out of date. Other reasons for STEM graduates not entering the field later in life might be the need to invest in postgraduate qualifications or the terms and conditions of employment.

However, the argument that out-dated skills or the need for more advanced qualifications is preventing older STEM graduates gaining HS STEM employment is weakened by the evidence of considerable numbers of non-STEM graduates entering HS STEM employment. Unless the internal division of labour within the STEM sector means that STEM graduates and non-STEM graduates are entering very different positions, it does not appear to be the case that a high level of STEM skills and knowledge is necessary to enter the sector. It seems more likely that large proportions of STEM graduates are not entering HS STEM jobs either because they do not want to (perhaps because pay and conditions are better in other sectors) or because employers are prioritising factors other than subject knowledge – such as degree classification or where the graduate studied. As we show later in this report, there is certainly evidence that the higher education institution that STEM graduates attended impacts on the likelihood of them entering HS STEM employment.

There is considerable variation in the employment destinations of STEM graduates, with those holding engineering degrees being much more likely to work in shortage areas or HS STEM jobs than those with physical or biological science qualifications. Even among engineering graduates, however, there is considerable movement out of professional engineering roles over the course of their careers, some movement away from HS STEM jobs, and no evidence of movement into these positions by older workers.

However, perhaps the most important finding is the number, and proportion, of non-STEM graduates working in HS STEM occupations over the course of the study. At every sweep from age 26 to 42, a substantial minority of non-STEM graduates held HS STEM positions. In numerical terms, this group outnumbered STEM graduates working in similar positions. As is shown in the next section, STEM graduates make up only a minority of those in HS STEM occupations, and many positions are filled by graduates with non-STEM degrees or those without any higher education qualifications. This is particularly important given that policymakers and employers often focus on STEM graduates. As non-STEM graduates and non-graduates are much larger groups than STEM graduates, they may represent a more fruitful focus for future recruitment initiatives.

3.3 Non-graduates working in STEM fields

Analysis of APS data showed that just over half (53%) of HS STEM positions were held by non-graduates. Disaggregating the data by age group shows that this proportion is lower among younger workers (37% for those aged 25-29 years) but higher among older workers (64% for those aged 55-59 years) reflecting the increased participation in higher education over time (Table 5).

The proportion of non-graduates employed in the different SOC 3-digit occupational groups varied quite considerably. Only 11% of those working in health professional occupations (SOC221) were non-graduates, regardless of their age, whereas over half of respondents working as production managers (SOC112) at age 25-29 were non-graduates, a share that increased to 79% for those aged 55-59.

In terms of STEM 'shortage' occupations, just under half (43%) of ICT professionals were non-graduates. This varied considerably by age, however, with 35% of 25 to 29 year-olds and 50% of those aged 55-59 holding such posts without having degrees. Although large numbers of 25 to 39 year-olds are employed in these occupations, there are fewer older workers in absolute terms, reflecting the relative youth of this sector.

Table 5: Percentage of positions held by non-graduates in key occupational sectors, by age, APS data, 2004, 2006, 2008 and 2010 (combined)

SOC Group	All Respondents		Age 25 - 29		Age 35 - 39		Age 45 - 49		Age 55 - 59	
	N	%	N	%	N	%	N	%	N	%
Prod man. (112)	12811	72	486	58	1944	66	2242	73	1641	79
Func man. (113)	24877	54	1754	42	4584	49	4003	57	2073	65
Sci prof (211)	2468	22	401	7	376	18	316	33	191	32
Eng prof (212)	8864	60	885	43	1317	54	1272	67	1033	70
ICT prof (213)	7718	43	1184	35	1619	42	913	49	420	50
Health prof (221)	6210	11	715	10	1019	11	908	11	535	11
Teach prof (231)	26757	21	2546	8	3221	14	3861	20	4165	34
Legal prof (241)	2910	10	389	4	483	8	376	10	294	16
Bus prof (242)	6779	36	841	23	1137	34	929	38	670	48
Sci/Eng tech (311)	4606	79	474	62	652	76	713	85	603	84
IT tech (313)	3161	67	601	61	540	66	413	72	193	77
HS STEM job	69075	53	7951	37	11129	49	9893	59	6960	64
Graduate job	216473	54	21871	40	33396	52	33106	58	23196	61
All jobs	512632	77	53640	68	74954	75	77023	79	59905	82

Within the professional engineering occupational group (SOC212) 60% of all jobs were filled by non-graduates, rising to 70% among those aged 55-59 – the highest proportion of non-graduate employees among the SOC 2 professional occupations considered here. Professional engineering occupations employ a slightly higher proportion of non-graduates compared to the proportion entering HS STEM jobs in general, and compared to 'graduate-level' occupations overall. Even among those aged 25 to 29, 43% of engineering professionals are non-graduates.

There are a number of possible explanations for these trends in the professional engineering sector. It could be that there is a 'natural' ceiling to recruitment the pool of engineering graduates. It may be the case that no more than a third of those with engineering degrees want to work in the sector, regardless of the conditions of employment on offer (see Table 3). In that case, one way to increase the pool of 'suitable' candidates would be to increase the number of those studying for engineering degrees, in the knowledge that only one in three of these would enter the sector. This seems to be the preference of employers and the main thrust of recent policies. However, as is shown in later sections, the differential levels of recruitment of different social groups suggests either that only certain types of graduate want to enter the engineering labour market or, more likely, that employers select the majority of their workers from particular social and educational groups.

The most obvious alternative source of potential engineering professions is STEM graduates with non-engineering degrees. Given that the majority of professional engineers either have no degree or a degree in a non-STEM subject, STEM graduates would seem to be a relatively desirable pool of labour. It is difficult to believe that maths or physics graduates, for example, do not have knowledge and skills that are transferable to engineering, and they will also have other transferable skills associated with a university education. At present very few physical and biological science graduates embark on careers in the engineering sector (see Table 2). This may be because they have no desire to enter this area or because employers would prefer engineering graduates – or non-graduates with engineering experience – but if a shortage really exists it would seem strange to ignore the potential for recruitment from this group.

There are also a considerable number of non-STEM graduates working in HS STEM jobs. Given the large number of non-STEM graduates, a relatively small increase in the proportion of engineering professionals recruited from this group would result in a substantial increase in the absolute number of STEM workers. As is the case with engineering and physical science graduates, it is not possible to know the 'ceiling' to which recruitment in this group could be pushed, but it may the case that there is capacity for growth among the different groups of graduates without engineering degrees.

The number of potential workers in any group is an important but often overlooked consideration in discussions of STEM 'shortages'. STEM graduates are a much larger group than engineering graduates, and non-STEM graduates are even greater in number. Small proportions of workers recruited from large groups can be numerous in absolute terms. And the largest group of potential employees are non-graduates. The proportion of graduates in professional engineering positions is much lower than in other non-STEM areas – in the health and legal sectors, for example – where a degree level qualification has long been mandatory. As the majority of engineering professionals do not have degrees, it is important to question the extent to which an engineering degree – or a degree in any subject – is necessary to work as an engineering professional, or whether it is merely something that is desirable to employers. It is clear that a degree-level qualification is not needed to perform all SOC212 jobs, as many of these roles are currently carried out by non-graduates. As we argued above in relation to the HS STEM worforce, the focus on STEM graduates may be distracting from other viable ways of increasing the number of HS workers in the engineering sector.

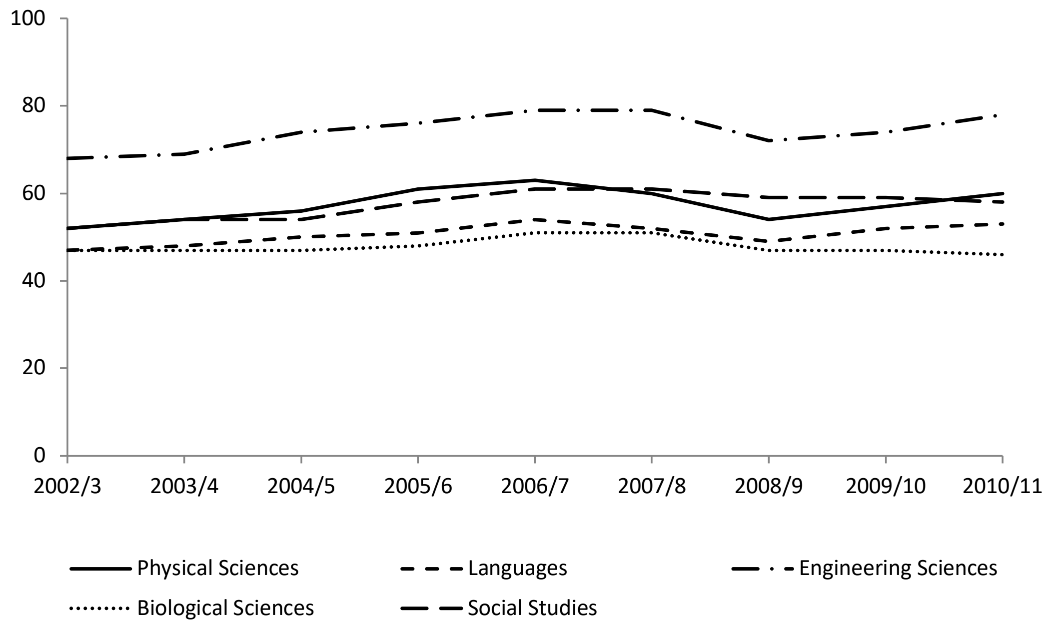
Changes over time in participation in the engineering labour market may partly reflect changes in participation in higher education. It is possible that there are higher proportions of older non-graduates in the sector simply because there are fewer graduates of that age in the population. The increase in the proportion of younger graduates in the engineering workforce might not be a consequence of changes in the nature of the work but merely the fact that more young people have degrees. However, it is important to consider that although this might be true for workers in their 50s and 60s, recruitment into engineering degrees has remained flat in absolute terms (at around 18,000 per year) since the early 1990s. The majority of the engineering workforce were educated in the last 30 or more years and so any increases in the number of engineering graduates entering the sector are likely to level off in the coming years.

4. How do patterns of employment in STEM occupations compare with employment patterns in non-STEM fields?

4.1 Participation in the labour market among recent STEM and non-STEM graduates

There were few differences in the overall proportion of STEM and non-STEM graduates entering graduate-level jobs shortly after they left university. Subject-level differences, however, did reflect the relative disadvantage of biological science graduates. Their employment outcomes were weaker than not only graduates from other STEM disciplines but also in comparison to some non-STEM subjects. Figure 4 compares the proportions of employed graduates in different subject areas who had entered graduate-level positions six months after graduating.

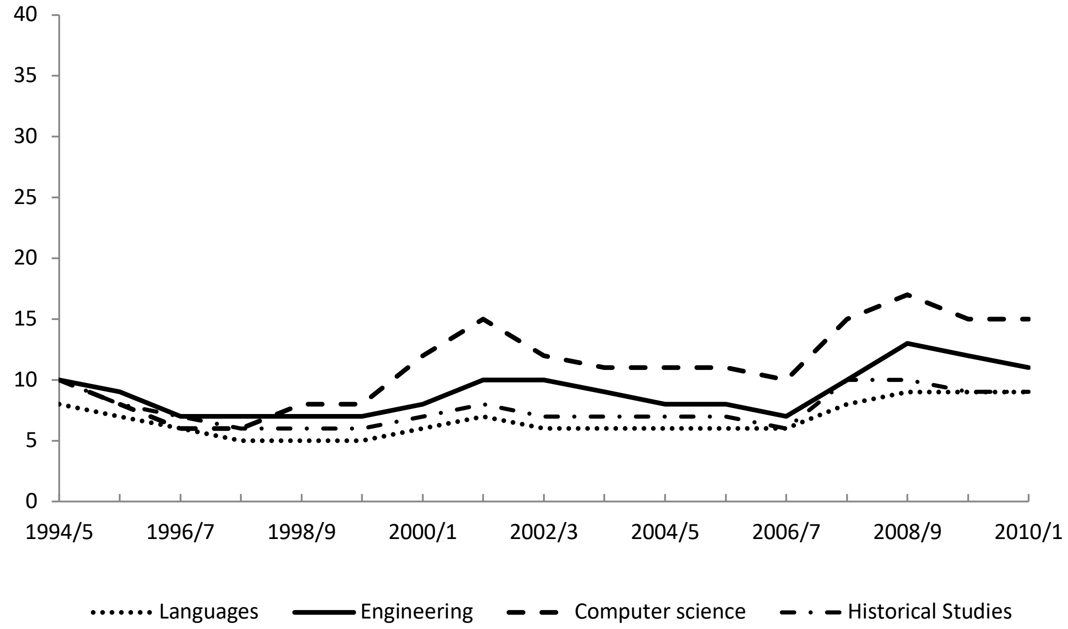
Figure 4: Percentage of students entering employment who gain 'graduate' type jobs, selected subject areas, HESA First Destination Surveys, 2002/3 to 2010/11



With the exception of engineering, there are relatively small differences between subject groups in the rates of graduate-level employment. Six months after graduating, around 70% of engineering graduates who found employment gained graduate-level positions. Physical science and social studies graduates had similar rates of graduate employment – fluctuating around and above 50% – albeit slightly lower than for engineering graduates. Those with languages and biological science degrees fared slightly less well but still had rates of over 40%.

These data show that, as a group, STEM graduates do not have substantially higher chances of obtaining graduate-level employment. While graduates from some subject areas – such as the engineering sciences – have better than average prospects in this respect, graduates in the biological sciences actually do slightly worse than their peers with languages and social studies degrees. Variation between STEM subjects is, in this respect, greater than the difference between STEM and non-STEM subjects at the aggregate level.

Figure 5: Proportion of graduates who were unemployed 6 months after graduation, selected subjects, HESA First Destination Surveys, 1994/5 to 2010/11



The HESA data on unemployment show similar patterns among STEM and non-STEM graduates, with few substantial differences between the main STEM and non-STEM subject areas (Figure 5). For example, over the period studied, around 8% of language graduates were unemployed six months after graduation, compared with approximately 10% of engineers. Engineering and computer science graduates have consistently had the highest rates of unemployment since 1998/9. While the rates for those with engineering degrees was only slightly higher than for historical studies or languages graduates, computer science graduates stand out as having the highest rates of unemployment. Although the differences are not dramatic, they are important because of the shortage discourse that surrounds these two subject areas. They raise the question of how higher rates of unemployment can persist in areas when employers complain of serious shortages.

Detailed findings

4.2 Employment patterns among STEM and non-STEM graduates in the wider workforce

Table 6: General occupational destinations of graduates, aged 25 to 64, all subject groups, APS data, 2004, 2006, 2008 and 2010 (combined)

	Graduate-level job		HS STEM job 1[2]		HS STEM job 2		Unemployed	
	N	%	N	%	N	%	N	%
Medicine and Dentistry	3182	98	2841	87	3111	96	24	1
Allied medical	6750	92	1652	22	6141	83	605	1
Biological Science	5531	82	2168	32	3856	57	179	2
Biology	983	83	390	33	710	60	33	2
Psychology	1678	79	554	26	1070	50	56	2
Vet/agricultural science	1023	74	587	42	707	51	38	2
Physical Science	5610	85	2673	41	4050	62	172	2
Chemistry	1827	88	930	45	1401	67	53	2
Physics	1163	91	621	48	912	71	43	3
Maths/computing science	6288	85	3418	46	4676	63	251	3
Mathematics	1950	87	839	37	1282	57	58	2
Computer science	3504	85	2163	52	2813	68	164	4
Engineering	7229	86	5148	61	5868	70	212	2
Technology	928	77	401	33	619	52	45	3
Architecture	2907	91	2180	68	2300	72	63	2
Social Studies	7702	81	1500	16	3357	35	260	2
Law	3552	88	315	8	558	14	106	2
Business and admin.	12284	81	3985	26	5604	37	412	2
Mass comms studies	1350	77	210	12	445	25	61	3
Languages/linguistics	4442	78	460	8	2639	47	162	2
Hist/Philosophical studies	3688	78	558	12	1899	40	140	2
Creative studies	4694	76	455	7	2253	36	219	3
Education	9378	90	273	3	8411	81	179	1
All STEM subjects	39448	87	21068	46	31328	69	1085	2
All non-STEM subjects	47090	82	7756	13	25166	44	1539	2
Total	86538	84	28824	28	56494	55	2624	2

2. Highly-skilled STEM 1 represents the UKCES definition of HS STEM work while HS STEM 2 uses Bosworth et al's (2013) definition. See Appenidx 2 for further detail.

Analysis of APS data showed that similar proportions of STEM and non-STEM degree holders, aged 25 to 64 and in employment, were working in graduate-level jobs. The data in Table 6 provide further evidence that differences between individual STEM subjects tend to be larger than those between STEM and non-STEM subject areas as a whole. For example, relatively low proportions of technology, creative studies and mass communications graduates worked in graduate-level jobs, compared with medics, dentists, architects and those with degrees in education. However, as mentioned previously, graduates were highly likely to be in graduate-level employment regardless of the subject they studied. Overall, the vast majority (84%) of graduates worked in graduate-level jobs, as did at least three-quarters of graduates from almost all subjects groups.

The APS analysis also shows the relatively high proportion (13%) of employed non-STEM graduates working in HS STEM jobs. One quarter of business and administration graduates worked in HS STEM jobs (as defined by UKCES, 2011), for example, with the proportion rising to over one-third when Bosworth et al.'s (2013) definition (HS STEM job 2 in Table 6) is adopted. It is worth noting that the large increase in non-STEM graduates working in HS STEM jobs under Bosworth et al.'s wider definition is largely due to the inclusion of all teaching and functional management occupations, two of the most popular graduate destinations regardless of subject studied.

There is also considerable variation between subjects in the proportion of STEM graduates working in HS STEM jobs. As noted earlier, relatively high proportions of engineering graduates work in HS STEM jobs. According to the APS data for the four years used in this study, 61% of engineering science graduates were employed in HS STEM roles. Much smaller proportions of technology (33%) and biological science (32%) graduates worked in these jobs (even when the wider definition of HS STEM occupations based on Bosworth et al.'s (2013) work are used).

There was little variation in the unemployment rates of older graduates with different degree subjects and certainly no noticeable difference between STEM and non-STEM subjects overall. Perhaps unsurprisingly, the proportions of graduates aged 25 to 64 who were unemployed was much smaller than at six months after graduating (as shown in the HESA data). However, as with recent graduates, computer science graduates stood out as having the highest rate of unemployment compared to other subject groups.

4.3 Occupational trajectories of STEM and non-STEM graduates

The BCS and NCDS provide comparative data on the occupational trajectories of STEM and non-STEM graduates. The majority of STEM and non-STEM graduates were employed in SOC1 or SOC2 occupations in every survey sweep of the two studies (see Table 7, for BCS data). SOC2 (Professional) occupations were the most common destination at every age point, with substantial proportions of both STEM and non-STEM graduates also finding employment in SOC1 (Managerial) and SOC3 (Associate Professional and Technical) jobs.

Non-STEM graduates lag behind their STEM graduate peers slightly, in terms securing SOC2 occupations, although they were more likely to enter SOC1 jobs at a younger age; many STEM graduates may have to work for nearly a decade before moving into managerial (SOC1) positions. As noted earlier in this report, movement into managerial roles appears to result in a smaller proportion of graduates working in HS STEM positions as the cohort aged. The proportion of STEM graduates in SOC2 jobs was highest at age 26, at 53%, but decreased in subsequent survey sweeps, stablising at 45% at age 38 and 42. By age 42 there were almost equal proportions of STEM and non-STEM graduates in both SOC1 and SOC2 jobs.

Table 7: SOC occupational outcomes for employed BCS70 STEM and non-STEM graduates, percentages, age 26 to 42

	Age 26		Age 30		Age 34		Age 38		Age 42	
%	STEM	non-STEM	STEM	non-STEM	STEM	non-STEM	STEM	non-STEM	STEM	non-STEM
SOC1	14	23	16	20	25	25	28	25	27	25
SOC2	53	39	51	35	51	41	45	39	45	43
SOC3	17	16	22	27	18	23	19	24	18	21
SOC4	8	16	5	10	2	8	3	9	4	6
SOC5-9	8	7	6	8	4	4	5	4	6	4
Total N	590	608	636	661	551	561	543	541	565	582

Although there are differences between the proportions of STEM and non-STEM graduates in SOC1 and SOC2 occupations at different points in their careers, there is certainly no evidence of an overall career advantage for cohort members with STEM degrees. In general, the jobs held by non-STEM graduates over the course of their careers were similar to those of STEM graduates. For both groups, teaching and functional management were among the highest recruiting roles. From age 34 onwards, the proportions of business and administration and biological science graduates working in HS STEM jobs was very similar. While the data in Table 7 are from the BCS70, the analysis of the NCDS produced similar findings, showing that these patterns are not unique to a particular cohort.

4.4 Occupational mobility among STEM and non-STEM graduates

A summary of mobility data from the NCDS is given in Table 8. The data represent all cohort members who participated in each of the last five sweeps (from age 33 to 55) and who have provided full occupational data. The columns show the proportion of these cohort members who have remained in that category (e.g. graduate-level employment) from age 33 to 55.

Table 8: Mobility of employed NCDS cohort members, ages 33 to 55

	Total (N)	Same SOC 3 digit (%)	Graduate job (%)	HS STEM job (%)	Same NS-SEC (%)
All cohort members	6582	13	17	3	17
Graduates	1038	25	51	10	25
Non-graduates	5544	11	11	1	16
Non-STEM graduates	493	23	46	2	23
STEM graduates	302	27	54	22	29
Engineers	105	17	51	19	20
Scientists	137	26	54	15	27
Soc/Business/Admin	217	15	41	2	17
Arts/Languages	135	22	44	2	21

Just over half of all graduates remained in graduate employment between the age of 33 and 55. The figure for STEM graduates (54%) was slightly higher than that for non-STEM graduates (46%), and this is reflected in the relatively high figures for engineering and science graduates. However, only 22% of STEM graduates, 19% of engineering graduates and 15% of science graduates remained in the HS STEM sector over this period. This is consistent with our findings from analyses of the BCS70 and APS data that show either movement out of HS STEM positions as cohorts age, or lower levels of HS STEM employment among older workers: a problem that appears to be particular to the STEM sector.

The patterns presented in this section can be summarised as follows. HESA data showed that similar proportions of employed STEM and non-STEM graduates are working in graduate-level jobs six months after they graduate. This pattern is reflected in the wider workforce, aged 24 to 65, as our analyses of APS data demonstrate. Engineering graduates stand out as having higher levels of graduate employment six months after graduating but, along with computer science graduates, this group also has higher levels of unemployment. Cohort data showed that any gap between the career success of non-STEM and STEM graduates closed in the decade following graduation.

Fewer than half of STEM graduates work in HS STEM occupations. Unsurprisingly, STEM graduates are more likely to work in HS STEM jobs than their counterparts with non-STEM degrees, but APS data showed that a surprisingly high proportion (13%) of employed non-STEM graduates aged 24 to 65 worked in such positions. Some subject areas, such as the biological sciences, had only slightly higher levels of HS STEM employment than non-STEM subjects such as business and administration.

A relatively small proportion of STEM graduates remained in HS STEM positions over the course of their careers and there was evidence suggesting that some moved into management positions. There was no evidence of any movement into HS STEM roles as cohort members aged.

The implication of these findings is that STEM degrees are certainly not a ticket to a more successful career. The occupational groups that all graduates enter, and move in and out of, are similar for most degree subjects. While STEM graduates are more likely to enter HS STEM jobs, such positions are also taken up by some non-STEM graduates and, regardless of subject background, relatively fewer workers stay in these positions than do in careers in other sectors.

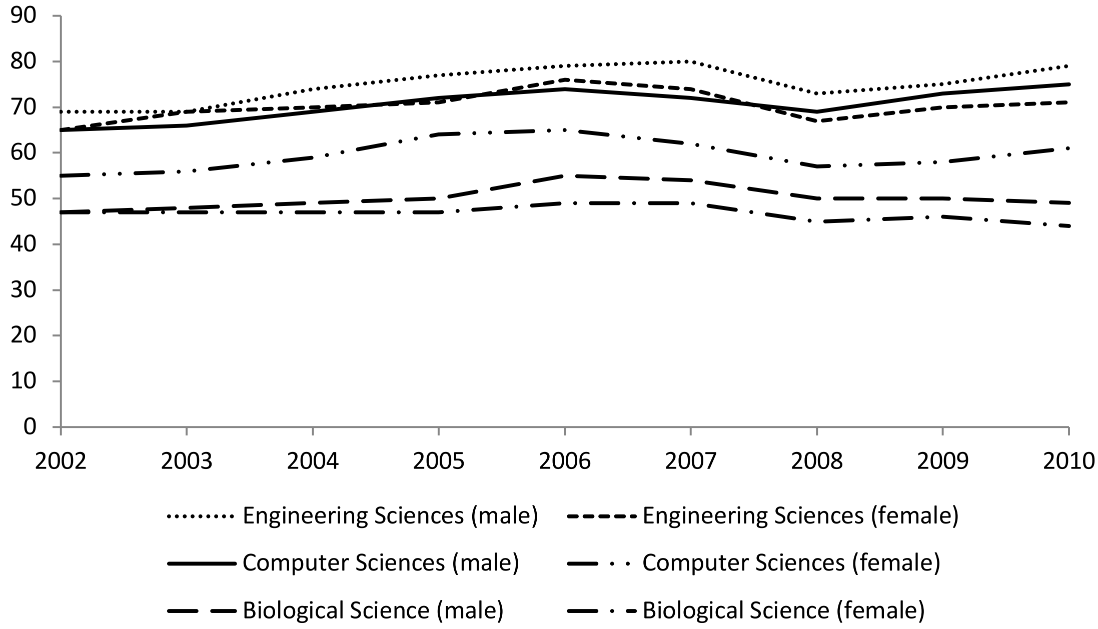
5. How closely is participation in STEM careers related to individual characteristics such as sex, age and educational background?

This research question is concerned with inequalities in participation. While there has been some work in this area already, most notably around female participation (e.g. Glover and Fielding 1999), there is limited recent work that uses cohort data to explore these issues. This section summarises the findings on differential participation in HS STEM occupations. As was argued earlier in this report, groups of STEM graduates that are under-represented in the HS STEM workforce could represent a valuable source of employees. Our findings show that some groups of STEM graduates are much less likely to be employed in HS STEM jobs than others, and it may be that more inclusive recruitment practices could help fill vacancies in the sector.

5.1 Differences between male and female STEM graduatess

There are clear differences in the type of STEM subjects male and female students study at university. Men are over-represented in the engineering sciences (in 2010/11 86% of undergraduates were male) as are women in the applied medical sciences (in 2010/11 81% were female). There were no large differences in the proportions of male and female STEM graduates entering employment or further study shortly after graduating, but male graduates were slightly more likely to be unemployed than females (11% in 2010/11 compared with 7% of women).

Figure 6: Percentage of STEM graduates entering graduate-level employment, selected subject areas, HESA First Destinations Surveys, 2002/03 to 2010/11



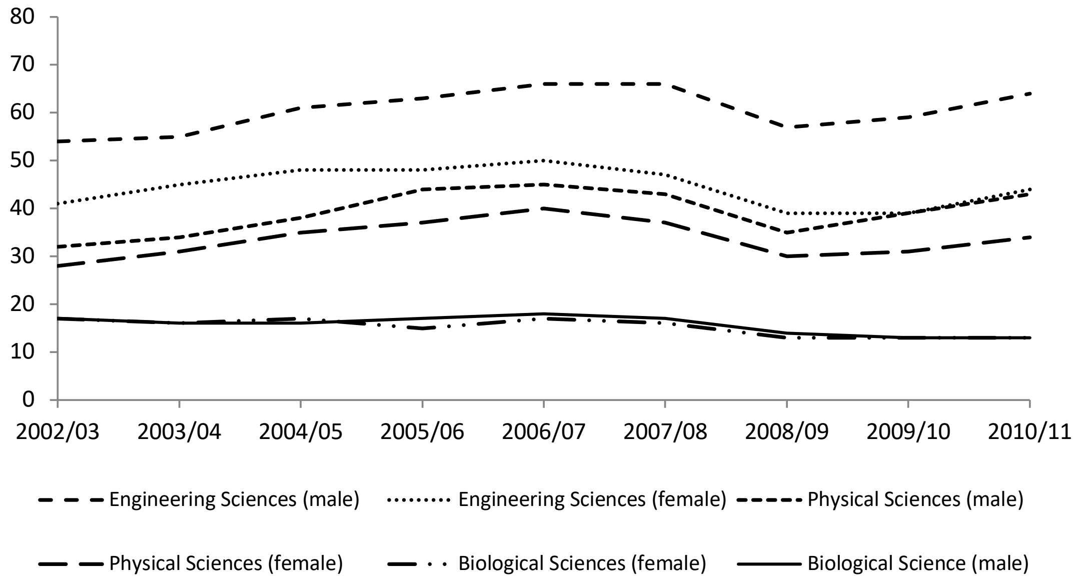
HESA data show that in most STEM subject areas, higher proportions of men than women enter graduate-level work within six months of graduating, but the extent of the gap does vary. Computer science had the largest difference with, for example, 75% of male but only 61% of female graduates securing these kinds of positions (Figure 6). The difference between male and female engineering graduates was much smaller (79% to 71%), and similar to the difference for biological science graduates (49% to 44%), although it should be considered that in absolute terms there are many fewer female than male engineering graduates.

So in terms of entry to graduate-level jobs, except for in the computer sciences, there appear to be only small differences between the destinations of male and female STEM graduates six months after graduation. Where larger differences occur they tend to be related to subject area rather than sex. For example, a far higher proportion of engineering science graduates of either sex enter graduate-level work compared to biological science graduates. Differences in early occupational destinations, in terms of securing a graduate job, are more closely aligned to the subject studied than whether a student is male or female.

The picture for employment in HS STEM jobs is very different, with men being substantially more likely to secure these kinds of jobs than women. Around a third of men but less than 20% of women enter this type of employment within six months of graduating with STEM degrees. However, there are important differences between STEM subject areas.

As can be seen in Figure 7, higher proportions of male engineers found work in HS STEM sector jobs compared with female graduates (64% and 44% in 2010/11). Patterns were similar for the computer sciences. Although the chances of gaining graduate-level employment were similar for male and female engineering graduates, a much smaller proportion of females were working in HS STEM positions six months after graduating. This is particularly important given that the general trend shown in the cohort study data was movement out from these jobs over time. Engineering graduates who are not in HS STEM jobs shortly after graduating are very unlikely to move into these kinds of occupations later. This evidence suggests that the majority of female engineering graduates will never work in HS STEM positions at any time in their careers. The situation for female computer science graduates is similar.

Figure 7: STEM graduates in HS STEM employment, selected subject areas, HESA First Destinations Surveys, 2002/3 to 2010/11



5.1.1 Differences between older male and female STEM graduates: Evidence from the Annual Population Survey

This section examines the occupations of older STEM graduates aged between 25 and 64. Table 9 summarises patterns of participation in graduate jobs, HS STEM jobs and the largest SOC 3-digit occupational groups for male and female STEM graduates from selected subject areas.

There are only very small differences in the proportion of male and female STEM graduates who enter graduate-level occupations but much larger differences in the percentage employed in HS STEM roles. More than 85% of male and female STEM graduates worked in graduate-level jobs but the proportions employed in HS STEM roles differed considerably, with 55% of males and only 32% of females in these positions.

Analysis of the main SOC 3-digit occupational groups reveals substantial differences in the types of roles taken by men and women, and suggests that the patterns found in the HESA data do not only apply to occupational destinations six months after graduation. Table 9 shows the occupational groups with the highest proportions of STEM graduates. While 23% of male STEM graduates held positions in the key STEM shortage occupations – SOC211, SOC212 and SOC213 – the proportion of women who occupy these roles is, at 7%, much smaller.

The inequalities in the proportion of female computer science graduates working in ICT found in the HESA data are reflected in the APS data, which shows that this difference is not restricted to destinations shortly after graduation. Only 12% of female computer science graduates aged 25 to 64 worked as IT professionals (a key shortage area) compared 31% of their male peers. The largest occupational groups for female STEM graduates were teaching and health (SOC221, SOC231 and SOC321), with 13% of employed female STEM graduates working as health professionals, compared with 9% of male STEM graduates. A larger proportion (16%) of female STEM graduates worked as assistant health professionals (SOC321) but the proportion of male STEM graduates working in this lower status group was very small, at only 1%. There is clearly a difference not only between the occupational sectors that male and female STEM graduates work in, but also the status of those positions.

The teaching profession (SOC231) continued to be an important graduate employer well after graduation – especially for non-medical STEM graduates – and one in which women were significantly over-represented, regardless of the STEM degree they studied. Nearly twice the proportion (12%) of employed female STEM graduates worked as teaching professionals compared to males (7%). There is variation between subject areas, however. Around 10% of employed male maths and computer science graduates worked as teaching professionals but 26% of female graduates with degrees in these subjects were employed as teachers. In other subject areas the difference was not so stark with, for example, 17% of female and 14% of male graduates in the biological sciences working in this area. In all of the core STEM subject areas, however, larger proportions of female than male graduates work as teachers.

Table 9: Percentage of employed male and female STEM graduates, aged 25 to 64, in selected STEM occupations, APS data, 2004, 2006, 2008 and 2010 (combined)

	All STEM graduates		Engineering Sci.		Math/Comp Sci.		Biological Sci.		Physical Sci.	
%	M	F	M	F	M	F	M	F	M	F
Graduate job	87	86	85	82	85	81	80	78	86	79
HS STEM job	55	32	61	53	52	31	33	30	44	32
Production manag (112)	7	1	15	6	2	1	2	1	6	1
Functional manag (113)	11	5	10	9	17	10	11	6	13	8
Science profess(211)	3	4	0.3	3	0.4	0.1	11	10	10	9
Engineering profs (212)	10	1	28	22	2	0.5	1	0.3	5	2
ICT professionals (213)	10	2	7	5	31	12	3	1	7	2
Health profess (221)	9	13	0.2	1	0.1	0.2	5	8	1	2
Teaching profs (231)	7	12	4	6	10	26	14	17	13	21
Bus. Stats profs (242)	2	2	2	3	5	8	2	2	3	3
Arch, planners. etc. (243)	5	2	2	2	0.2	0	0.2	0.1	1	1
IT delivery occup. (313)	2	1	1	2	6	3	1	1	2	1
Ass. Health profs (321)	1	16	0.2	1	0.1	0.5	1	3	0.5	1
Therapists (322)	1	7	0	0.4	0.1	3	1	2	0.1	1
Total N	28144	17402	7755	676	5416	1976	2862	3901	4531	2044

In the context of this imbalance, it is useful to reflect on the number of males and females who study these subjects. The frequencies in the bottom row of Table 9 reflect the APS samples, rather than population data, and are the result of combining different subject years. Population data on differential participation in STEM subjects by males and females is widely available from UCAS and we have discussed in detail in previous publications (Smith 2010, 2011, Smith & Gorard 2011, Smith & White 2011). However, the figures in Table 9 give a sufficiently accurate picture of the unequal participation to highlight the fact that the effects of the differences in the proportions of male and female STEM graduates entering the teaching workforce can only be seen once the number of male and female graduates in a particular subject area have been taken into account. So, for example, we might still expect to have more male than female teachers with physical science degrees because, even though much larger proportions of female graduates from this subject area enter teaching, many more male students take these subjects at university. The same would be expected to be true for the engineering sciences and, if the APS data can be considered representative, even in maths and computer sciences (where the imbalance between male and female participation in teaching is largest). Because female biological science graduates outnumber their male peers, however, the imbalance in participation in teaching is magnified, explaining why the majority of teachers with biological science degrees are female.

It is important to note that there is unlikely to be an exact correspondence between undergraduate degree subject and subject taught as a teaching professional. However, because of the requirements (or at least preferences) of both trainers and employers, any differences are unlikely to change the patterns that we have discussed. The key point is that the disproportionate participation in teaching by female STEM graduates does not mean that females will be fairly represented in the science teaching workforce. The APS data suggest that, in all subject areas apart from the biological sciences, most teachers with STEM degrees will be male.

Occupational patterns among STEM graduates as a whole reflect those for recent university leavers and point to the robustness of patterns of inequality in the STEM sector. Most notably, the data reveal that women, especially those who study subjects in which they remain a minority (such as engineering and computing), remain under-represented in HS STEM jobs in general, as well as in many areas where shortages are often claimed. Disproportionate numbers of female STEM graduates enter particular areas of the labour market – such as teaching and healthcare – and they are also over-represented in some lower status, associate professional, occupational groups.

5.1.2 Older male and female STEM graduates: Evidence from the cohort studies

Table 10 shows the proportion of employed female and male STEM graduates working in graduate jobs, and the percentage working in the highest recruiting SOC occupational groups, at the five cohort sweeps between the ages of 26 and 42. At age 26, over 82% of female STEM graduates were working in graduate-level jobs, a figure that increased to 88% by age 30 and 91% by age 34. The HESA data summarised above showed that similar proportions of male and female STEM graduates found work in graduate-level employment shortly after graduating, and the APS data show that these proportions are similar for female workers in their forties and younger. The findings from the analysis of the BCS70 data are consistent with those results but provide a useful longitudinal perspective.

Across each sweep of the study, the SOC2 (professional) occupational group was the most common employment type for both male and female STEM graduates. A slightly smaller proportion of women than men were working in SOC2 jobs from ages 26 to 34, although the gap narrowed as the proportion of STEM graduates of either sex working in SOC2 roles fell from age 38. However, men were considerably more likely to work in SOC1 managerial occupations at every sweep of the survey. This difference was largest at age 30, with only 11% of employed female STEM graduates employed in managerial positions, compared to 20% of men with STEM degrees. It was smallest only four years later at 22% and 27%, respectively, but the gap increased in subsequent sweeps.

Women, on the other hand, were more likely than men to work in SOC3 associate professional jobs; just under a third (31%) of female STEM graduates were in these jobs at age 30, compared to only 16% of their male peers. This gap persisted as cohort members aged, with 23% of employed female STEM graduates working in associate professional positions at age 42, compared to only 15% of their male peers.

At every sweep of the BCS70 the most popular SOC2000 3-digit occupational destinations for women were teaching (SOC231) and health professional (SOC221) roles. At age 42 nearly one-third (32%) of female STEM graduates worked in these two areas and 10% worked as functional managers (SOC113). In contrast, the proportions of female STEM graduates working in the three main STEM shortage areas – SOC211, SOC212 and SOC213 – were relatively small, especially in engineering and in ICT, where at no sweep did these two groups account for more than 12% of the cohort of female STEM graduates. Unlike employment in education and health, the proportion of this group working in these shortage areas declined as cohort members got older, to only 5% by age 42.

Jobs in teaching and health were relatively common among male STEM graduates at every sweep but the proportions working these areas were markedly lower than for their female peers. Until the age of 38, ICT professional roles were the most popular destination for male STEM graduates, at which point a larger proportion were working in functional management. There is further evidence here to suggest that much of the attrition from the key shortages areas of science, engineering and ICT is into functional management roles, particularly among male STEM graduates. The female dominated areas of teaching and health did not appear to suffer from similar patterns of attrition and were relatively stable in terms of recruitment and retention over time.

Despite similarities in the proportions of graduates of both sexes who entered and stayed in graduate-level jobs, there were substantial differences in the percentage of men and women who entered HS STEM jobs (Table 11). While female graduates were as likely as men to gain graduate-level employment, they were far less likely to work in highly-skilled STEM jobs, regardless of the stage of their career.

Table 10: BCS70: Main graduate occupational groups for employed female and male STEM graduates, ages 26 to 42

	Age 26				Age 30				Age 34				Age 38				Age 42			
	Female		Male		Female		Male		Female		Male		Female		Male		Female		Male	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Graduate jobs	236	82	354	84	243	88	393	87	191	91	360	92	202	89	341	91	217	87	348	89
Highest recruiting SOC 2000 Occupational Groups																				
Managerial (SOC1)	22	9	58	16	28	11	77	20	42	22	96	27	36	18	117	34	46	21	108	31
Functional managers (113)	10	4	24	7	10	4	39	10	18	9	55	15	16	8	59	17	21	10	53	15
Professional (SOC2)	120	51	192	54	113	46	211	54	92	48	191	53	91	45	155	45	98	45	156	45
Science professionals (211)	11	5	14	4	12	5	15	4	11	6	14	4	8	4	8	2	6	3	10	3
Engineering profs (212)	9	4	34	10	4	2	32	8	5	3	27	7	2	1	21	6	2	1	20	6
ICT professionals (213)	8	3	54	15	10	4	67	17	2	1	58	16	3	1	38	11	3	1	37	11
Health professionals (221)	32	14	27	8	28	11	22	6	24	13	23	6	21	10	29	8	28	13	32	9
Teaching profs (231)	38	16	24	7	38	16	20	5	30	16	22	6	38	19	18	5	42	19	24	7
Business/stat profs (242)	12	5	11	3	5	2	12	3	5	3	20	6	5	2	16	5	5	2	12	3
Associate profess (SOC3)	53	23	48	14	75	31	64	16	44	23	53	15	57	28	45	13	50	23	53	15

Table 11: Employed BCS70 cohort members working in HS STEM jobs, ages 26 to 42

	Age 26				Age 30				Age 34				Age 38				Age 42			
	Female		Male		Female		Male		Female		Male		Female		Male		Female		Male	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
All CM	3591	7	3312	19	4236	9	4860	20	3729	9	4260	22	3642	9	3847	24	4055	8	4238	21
All graduates	762	19	713	44	898	20	956	43	742	19	857	46	720	18	825	42	782	16	837	38
STEM graduates	236	40	354	59	243	39	393	61	191	39	360	59	202	33	341	54	217	31	348	53
Biological sciences	50	32	32	34	53	30	36	36	47	34	29	28	49	22	32	25	50	20	34	32
Physical sciences	48	35	79	46	59	41	92	55	39	36	85	52	44	23	82	49	51	25	86	49
Maths & computing	34	29	77	60	31	26	80	62	23	26	75	56	26	35	68	48	29	21	70	43
Engineering	16	81	96	67	14	64	107	63	12	50	96	63	13	54	88	61	12	50	89	57

Across all five sweeps of the BCS70, over 50% of male STEM graduates worked in HS STEM jobs. But for female STEM graduates, the figure was around twenty percentage points lower than their male peers at each sweep of the study. At age 30, for example, 61% of male STEM graduates were working in HS STEM jobs, whereas for female STEM graduates the figure was only 39%. As was the case with men, the proportions of female STEM graduates in HS STEM roles fell in subsequent sweeps of the cohort study – from 39% at ages 30 and 34, to 31% at age 42.

5.2 Institutional differences in early STEM careers

HESA early destination data was used to compare the career trajectories of graduates from two different groups of British universities: the Russell Group (RG) and University Alliance/Million+ (UA/M) institutions. There were similar proportions of STEM students in both types of institution, although numerically more STEM students studied at UA/M+ universities. There were also clear institutional differences in the subjects taught at both types of institution. For example, medicine, dentistry and the physical and mathematical sciences were more likely to be taught in in RG institutions, and computer science, psychology, sports science and forensic science were more common in UA/M+ universities.

The characteristics of students at both types of institution also differed, with 25% of undergraduates in RG universities having been educated in the private sector compared with only 4% of those in UA/M+ institutions. These patterns were similar for both STEM and non-STEM students. Programmes at RG institutions typically required higher entry grades than those needed for entry to UA/M+ institutions and variation in entry grades between subject areas within RG institutions was relatively small. However for UA/M+ institutions, entry grades were much more variable, with popular and growing subjects such as psychology requiring higher entry grades than subjects such as electrical and electronic engineering, and computer science.

Similar proportions of graduates from Russell Group and University Alliance/ Million+ institutions entered employment upon graduation. Unemployment levels were also similar, although RG graduates were more likely to remain in further study. However, graduates from RG institutions were more likely to enter graduate-level jobs than those from UA/M+ universities (Table 12) and STEM graduates from both types of institution were generally more likely to secure graduate jobs than non-STEM graduates within six months of finishing their degrees.

In UA/M+ institutions, the three subject groups (excluding medicine and dentistry) with the highest proportion of graduates entering graduate-level employment were the allied medical sciences, the engineering sciences and the computer sciences. However, the proportion entering graduate jobs from the latter two subject groups lagged behind those from the RG by as much as 20 percentage points in some years (Table 12).

Table 12: The percentage of graduates who enter employment and are working in graduate level jobs six months after leaving university. HESA First Destination Surveys, 2002/03 to 2010/11

	Russell Group			UA/M+		
%	02/03	06/07	10/11	02/03	06/07	10/11
All STEM subjects (except M/D)	66	74	74	65	69	64
All non-STEM subjects	54	63	63	50	58	52
All subjects	63	72	72	57	63	57
Allied to medicine	82	84	84	91	88	86
Biological sciences	49	55	52	44	47	42
Biology	47	55	57	48	53	44
Psychology	46	51	52	39	40	36
Veterinary science	93	99	95	15*	60*	56*
Agriculture & related	58	49	54	52	48	38
Physical sciences	54	68	68	52	54	48
Chemistry	63	76	73	78	68	61
Forensic science	34*	51*	39*	59*	56*	42
Physical geography	47	59	51	49	48	41
Mathematical sciences	59	73	76	63	72	54
Computer science	72	86	90	60	69	67
Engineering & technology	77	87	87	60	70	68
Civil engineering	89	94	91	81	89	69
Mechanical engineering	73	84	87	60	75	78
Electric/electronic engineering	75	88	87	56	67	65
Arch., building & planning	91	93	76	83	91	75

*Small N (less than 50).

In general, STEM graduates from RG institutions were approximately twice as likely to enter HS STEM jobs than those from UA/M+ institutions (Table 13). Employment in HS STEM roles among recent graduates from RG institutions was as high as 61% in 2006/7 but only was at only 31% among those from UA/M+ institutions in the same year. (An important exception to this is biology, where similar proportions of graduates from both types of institutions who find jobs do so in the HS STEM sector.) In the context of 'shortage' discourses, the proportion of STEM graduates from UA/M+ institutions going into HS STEM roles appears very low.

The particularly large gap between the proportion of UA/M+ STEM graduates who are able to find graduate-level employment and the proportion entering HS STEM roles suggests that this group of graduates may be being overlooked or under-recruited by employers. Around two-thirds of these STEM graduates from these institutions are successful in terms of gaining graduate-level positions but less than one-third are either unable or unwilling to find work in the HS STEM sector.

The numbers involved here are large. Almost 10,000 undergraduates study computer sciences in UA/M+ institutions in any given year, but the career outcomes for this group are very different to RG graduates in terms of HS STEM employment. Only around 50% of computer science graduates from UA/M+ institutions enter HS STEM jobs, compared with more than three-quarters of RG graduates. While proportionally more computer science graduates enter HS STEM jobs than do graduates from other science subjects, such as biology, the relatively low levels of HS STEM employment among UA/M+ graduates exist alongside a discourse of workforce shortages in the tech industry. There is a clear difference between the employment prospects of computer science graduates who study at UA/M+ and RG institutions that raises questions about both the career plans of these graduates and recruitment practices in the STEM sector.

Table 13: Proportion of graduates who enter employment and are working in HS STEM jobs six months after leaving university, HESA First Destination Surveys, selected years, 2002/03 to 2010/11

	Russell group			UA/M+		
	02/03	06/07	10/11	02/03	06/07	10/11
All STEM subjects	53	61	60	29	31	26
All non-STEM subjects	16	22	22	8	10	8
All subjects	35	42	42	17	19	15
Medicine & dentistry	99	99	100	-	100*	100*
Allied to medicine	32	27	24	11	9	12
Biological sciences	25	26	23	13	12	8
Biology	25	30	28	28	33	25
Psychology	18	18	14	8	9	5
Veterinary science	89	99	93	6*	40*	44*
Agriculture & related	38	33	31	26	24	21
Physical sciences	33	48	47	28	33	30
Chemistry	42	55	52	62	47	44
Forensic science	13*	30*	14*	41*	33	27
Physical geography	24	34	27	24	27	18
Mathematical sciences	41	55	59	20	38	32
Computer science	60	75	80	43	52	49
Engineering & technology	62	75	74	44	51	53
Civil engineering	83	90	74	73	86	57
Mechanical engineering	62	75	79	53	63	71
Electric/electron engineering	60	77	80	39	56	48
Arch., building & planning	84	88	66	73	81	59

*Small N (less than 50).

The short-term career destinations of engineering graduates, who have the highest level of graduate employment in HS STEM jobs of all non-medical STEM subjects, also differ according to the type of institution the student attended. The gap between RG and UA/M+ engineering and technology graduates entering HS STEM jobs is similar to that for computer science graduates. In areas such as civil and mechanical engineering the differences are not huge, but electrical and electronic engineering graduates from UA/M+ institutions were substantially and consistently less likely than those from the RG to enter HS STEM jobs.

It is important to note that, in absolute terms, there are about twice as many electrical and electronic engineering students in UA/M+ universities than in RG institutions. The fact that almost half of all graduates in these subjects from UA/M+ institutions do not find HS STEM jobs within six months of graduation means that large numbers of qualified graduates are not entering a sector that is apparently blighted by labour shortages.

Institutional type differences are less evident in biology, where only just over one quarter of graduates from either type of institution entered HS STEM jobs. It may be the case, however, that as higher proportions RG biology graduates enter postgraduate study (in 2010/11 34% from RG institutions compared with 22% from UA/M+) these figures would eventually be higher for those graduating from RG institutions. Nevertheless, this does underline the points made earlier about postgraduate, as opposed to undergraduate qualifications, being the gateway qualification to many HS jobs in the STEM sector.

There are clear differences between the short-term career destinations of STEM students from different types of higher education institution. These are evident in the proportion of employed graduates working in graduate-level employment but are much more pronounced in relation to finding work in HS STEM positions. There are important differences between STEM subjects, but our main concern here is with the destinations of students studying ‘shortage’ subjects such as engineering and computer science. While relatively high proportions of employed RG graduates in these areas are in HS STEM jobs six months after graduating, much smaller proportions of those from UA/M+ institutions are in these positions. The lower level of recruitment into HS STEM jobs among this group raises important questions both about the career aspirations of these graduates and the recruitment practices of employers.

An important finding from these analyses are the differences between the career destinations of students with particular degrees. It is not simply the case that RG STEM graduates from all subjects have dramatically higher rates of HS STEM employment compared to their UA/M+ peers, and for some subjects there are only very small differences in employment outcomes. There may be important lessons to be learned from closer investigation of the differences in the career destinations between graduates with degrees in these subjects.

5.3 Ethnicity

Because analyses of ethnicity using the cohort study data (BCS70 and NCDS) resulted in cell sizes that were too small to be useful, we have only included the results of the analyses conducted with the APS. Around 84% of the APS sample identified themselves as White (British and Northern Irish) with the next largest group comprising White Other (6%). The largest non-white group consisted of respondents identifying as Indian(around 4% of all respondents). In addition to Indian students, four minority ethnic groups had more than 1000 graduate respondents: Chinese, Pakistani, Asian (other) and Black African. Proportionally more graduates of Indian and Chinese origin had studied STEM subjects (55% and 53% respectively) compared with 43% for White British and 42% for Black African. As the number of respondents from the other minority ethnic groups was relatively small and our analyses involved dividing these into further sub-groups, the conclusions that can be drawn here must be tentative and the discussions of our findings focus only on those groups for whom we have data for more than 1000 respondents.

There were some differences in the proportions of graduates from different ethnic backgrounds working in HS STEM jobs. STEM graduates from Chinese and Indian ethnic backgrounds were more likely to work in HS STEM jobs than those from the other main ethnic groups. Subject-level differences were also apparent, with a relatively high proportion of Indian maths and computer science graduates working in HS STEM jobs, for example, but numbers here tend to be small and these findings should be treated with caution.

Table 14: STEM Graduates in HS STEM jobs, selected ethnic groups, APS data, 2004, 2006, 2008 and 2010 (combined)

	Biological sciences		Physical sciences		Math/Comp sciences		Engineering		All STEM graduates	
	N	HSS job %	N	HSS job %	N	HSS job %	N	HSS job %	N	HSS job %
White British/NI	5765	31	5842	40	5810	46	7011	62	37769	47
Other White	453	39	295	50	421	46	509	57	2629	50
Indian	154	34	124	35	422	54	282	57	1638	60
Pakistani	46	28	43	33	154	41	69	44	506	52
Other Asian	46	33	31	36	77	44	112	53	503	43
Black African	67	34	44	48	121	46	79	56	555	47
Chinese	33	58	26	69	100	52	87	53	385	57
TOTAL	6741	32	6551	41	7354	46	8384	61	45324	46

5.4 Geographical location

As the APS gathers data on respondents' region of work, we were able to examine geographical variation in employment. Around 40% of all employed graduate respondents worked in London or the South East, compared with about a quarter of the APS sample as a whole.

There were some regional disparities in terms of graduates working in graduate and/or HS STEM jobs. Overall 27% of STEM graduates in a graduate-level job were working in London and the South East, compared with 30% of non-STEM graduates. Higher proportions of physics, mathematics and computer science graduates were working in London and the South East than graduates from other STEM subject areas – pointing to a concentration of ICT related skills in this region (Table 15).

Table 15: Regional differences in participation for employed graduate, graduate-level and HS STEM jobs, APS data, 2004, 2006, 2008 and 2010 (combined)

	Graduate-level job		HS STEM job	
	Total (N)	London/South East (%)	Total (N)	London/South East (%)
Medicine and Dentistry	3173	23	2832	23
Allied medical	6736	20	1647	23
Biological Science	5516	28	2159	28
Biology	982	24	388	22
Psychology	1675	33	553	33
Vet/agricultural science	1020	17	585	17
Physical Science	5585	28	2657	30
Chemistry	1820	25	925	26
Physics	1157	33	617	35
Maths/computing science	6277	34	3410	37
Computer science	3494	35	2156	37
Engineering	7165	27	5094	25
Technology	925	27	401	29
Architecture	2902	28	2179	29
All STEM subjects	39299	27	20964	28
All non-STEM subjects	46966	30	7731	36
Total	86265	29	28695	30

This distribution was similar for those working in HS STEM jobs. Over a third of employed graduates with physics, mathematics and computer science degrees worked in London and the South East, compared with 28% of all STEM graduates. Non-STEM graduates working in the HS STEM sector were more likely than STEM graduates to work in London and the South East. This may be explained by the relatively high proportion of non-STEM graduates who were working in business, statistical and financial occupational roles (SOC242).

5.5 Employment sector

Just over half of graduates working in graduate-level roles were based in the private sector, compared with three-quarters of those with HS STEM positions. Similarly, a higher proportion of those in SOC1 occupations were based in the private sector, compared with those in SOC2 and SOC3 jobs.

There were considerable variations within occupational groups: around 90% of graduate engineering professional jobs were in the private sector, compared with 14% of those in teaching professional jobs and 13% of those working in the associate health professions.

Subject-level differences reflect the patterns seen earlier. Biological science graduates were much less likely to work in the private sector than engineering graduates, for example. The vast majority of those working in ICT and engineering professional occupations (SOC212 and SOC213, two of the key shortage areas) were based in the private sector.

Table 16: Percentage of graduates working in the private sector, 2004, 2006, 2008 and 2010 (combined)

	All Graduates		Engineering		Math/Comp Sci.		Biological Sci.		Physical Sci.	
	N	%	N	%	N	%	N	%	N	%
Graduate job	98952	56	7214	85	6273	70	5521	46	5600	63
HS STEM job	32537	74	5133	90	3403	83	2164	46	2668	76
SOC 1	26129	80	2700	90	1690	83	1233	80	1629	86
Production managers (112)	3577	93	1179	95	123	91	95	87	272	96
Functional managers (113)	11462	85	877	93	1136	84	559	83	771	88
SOC 2	49383	45	3706	83	3724	65	2854	30	2885	53
Science professionals (211)	1930	50	43	70	24	37	700	36	641	68
Engineering profs (212)	3539	91	2322	91	101	85	42	96	280	93
ICT professionals (213)	4372	90	587	94	1937	90	116	82	358	91
Health professionals (221)	5525	45	19	37	11	27	450	25	90	64
Teaching profs (231)	21053	14	332	11	1054	16	1075	15	1012	14
Bus. Stats profs (242)	4349	85	161	92	447	83	120	82	209	85
Arch, planners. etc (243)	1987	79	158	83	13	85	9	33	52	58
SOC 3	25018	56	1056	75	1086	68	1554	53	1207	59
IT service delivery (313)	1047	69	98	74	357	67	51	61	94	70
Ass. Health profs (321)	4187	13	17	18	18	6	174	19	48	19

This raises important considerations for who should fund specialist and advanced training for HS STEM workers. If the majority of these jobs are based in the private sector then to what extent should employers, rather than the taxpayer or the employee, fund specialist training to meet the needs of the sector? As further discussed elsewhere in this report, it raises wider questions about the relationship between higher education and industry, and the role of universities more widely.

6 Can multivariate analysis help predict participation in STEM careers?

Multivariate statistical modelling was used in an attempt to move beyond bivariate analysis and provide a more sophisticated description of the factors associated with participation in the STEM labour market. The HESA data sets were the largest but, because the data were not available at the level of individual cases, did not allow for multivariate analysis. The numbers in the sub-groups of both cohort studies were too small to allow robust analysis, so multivariate analyses were only conducted using the combined years of the APS data.

Table 17: Odds ratios for logistic regression models of occupational outcome, APS data, 2004, 2006, 2008 and 2010 (combined)

All respondents – likelihood of working in a HS STEM job				
	Model 1	Model 2	Model 3	Model 4
Background characteristics				
Male	3.567	3.754	2.728	2.462
Age	0.989	0.994	0.986	0.988
White	0.869	0.952	0.800	0.768
Academic characteristics				
Graduate		3.925		8.155
STEM Graduate			4.972	
Engineering				4.188
Physical sciences				2.228
Biological sciences				1.860
Maths/computing sciences				2.541
Social sciences				0.705
Business and administration				1.194
N	592533	510521	102462	113866
% predicted correctly (86.6 base)	86.6	86.5	74.6	76.6
Nagelkerke pseudo-R2	0.075	0.151	0.233	0.202

The findings of the multivariate analysis add little to the simpler analyses presented earlier in this report. The model has fairly weak predictive power, explaining 23% of the variation at best. None of the four models presented in Table 17 are able to predict cases correctly over and above the original 86:14 balance of respondents in HS STEM and other jobs (although this is not uncommon in this kind of analysis). The odds ratios in the models confirm the findings presented earlier, with males at least 2.5 times more likely to work in HS STEM jobs than females and graduates much more likely than non-graduates. In terms of differences between subjects, the results largely reflect the previous analyses. Engineering graduates stand out as the most likely to enter HS STEM roles, followed by maths and computer science and physical science graduates. According to Model 4, biological science graduates appear slightly more likely to gain HS STEM occupations compared to the results of the simpler analyses presented above. However, it should be borne in mind that the predictive power of these models is low and so placing too much value on these figures would be unwise.

Discussion

At the start of this report we identified six statements that outlined patterns that we would expect to find in the data if there was a skills shortage. In this section we return to these statements and examine each in terms of the evidence produced in this study and in our previous research:

An increased level of participation in STEM degrees as universities responded to the calls from industry to recruit (and train) more students

The data show that patterns of participation in STEM subjects at university have remained flat – proportionally – over the last thirty years, although the number of entrants has risen in absolute terms. So while there are more STEM graduates than in previous years, studying science subjects at higher education is no more popular, in relative terms.

Any absolute increase in STEM recruitment to higher education, however, has been due to increased participation in subjects such as psychology and sports science, rather than 'shortage' subject areas such as engineering and physics. There is no evidence of a rush to study 'shortage' STEM subjects in order to take advantage of labour market opportunities. In fact, levels of recruitment to 'shortage' subjects have fallen behind in proportional terms.

These patterns have occurred in spite of the many costly initiatives aimed at increasing recruitment to shortage subjects. Initiatives to increase recruitment among female students have been similarly unsuccessful with, for example, the proportion of female engineering students remaining around 10% for many years.

High proportions of STEM graduates entering HS STEM jobs (especially in 'shortage' areas) after graduation

Only a minority of STEM graduates go into HS STEM occupations shortly after graduation and the proportion in these roles is smaller among older workers. There is also evidence that workers move out of HS STEM positions as their careers progress. There is considerable variation between STEM subjects, however. More than 50% of engineering graduates who gain employment shortly after graduation enter HS STEM employment but less than one-fifth of employed biological science graduates are recruited to HS STEM roles at the same point in their careers. There is little evidence of change over time in these patterns.

High levels of recruitment to, and little attrition from, shortage occupations

The three key STEM shortage occupations (science, engineering and ICT professionals) attract only a small minority of STEM graduates. Teaching and functional management are the highest recruiters of STEM graduates. STEM graduates who do not enter HS STEM roles shortly after graduating are very unlikely to ever move into the sector. Unlike in other areas – such as education and health – there is substantial attrition out of HS STEM roles, perhaps into management.

Favourable career trajectories for most (traditional) STEM graduates regardless of subject studied or higher education institution attended

There is little variation between the immediate and longer-term occupational destinations of STEM graduates in terms of graduate-level employment. The vast majority of graduates enter graduate-level work within a few years of graduating and remain in high status positions over the course of their careers. In this respect they have little advantage over non-STEM graduates, who fare equally well in the long term.

Differences in the proportion of STEM graduates entering HS STEM positions are more noticeable. As discussed above, engineering science graduates are most likely to enter HS STEM roles but biological science graduates fare less well than some non-STEM graduates. In terms of HS STEM employment, all STEM degrees are certainly not equal.

More favourable occupational trajectories for STEM graduates compared to non-STEM graduates, particularly those with degrees in 'shortage' subjects

Differences in employment outcomes between STEM subject areas are greater than those between STEM and non-STEM areas. There is no evidence of a general labour market advantage for STEM graduates in terms of their ability to secure graduate-level employment. Some STEM 'shortage' subject areas, such as engineering, have higher than averages levels of unemployment six months after graduation. There is some evidence of a lag in the time it takes non-STEM graduates to attain graduate-level jobs (especially professional (SOC2) jobs) but this may be due in part to the non-specialist nature of many non-STEM degrees.

Shortage occupations recruiting from a broad range of skills and backgrounds, with reduced inequalities in participation and retention

Sectors such as the engineering profession recruit from a narrow range of graduates; relatively few non-engineering graduates work in professional engineering roles, for example. However, large proportions of non-graduates are employed in this sector.

Female STEM graduates are as likely as men to enter graduate-level employment but less likely to secure work in HS STEM jobs.

The gap in employment trajectories is greatest for subjects with the largest inequalities in terms of male and female participation, and where the shortage discourse is most common, notably engineering and computer science.

STEM graduates from pre-1992 institutions are generally less likely to secure HS STEM jobs compared with graduates from more research-intensive institutions. This is particularly the case for engineering and computer science graduates. Given the tradition of the former polytechnics in providing industry with high-level vocational training, this is surprising. This is particularly important given that such a high proportion of professional engineering jobs are held by non-graduates, raising the question of the extent to which degree-level qualifications are actually required, and why so few graduates from certain types of institution go on to work in the sector.

To what extent is there evidence for a shortage?

As can be seen from the discussion directly above, there is very little evidence to support any of the indicators of shortages identified at the beginning of this report. There are now more students graduating with STEM degrees, in all subjects, than in previous decades, but no more than would be expected given the expansion of undergraduate education more widely. Undergraduate recruitment in 'shortage' STEM subjects has actually lagged behind the continued expansion of higher education, and participation in STEM subjects overall has only kept up proportionally because of increased recruitment to the 'newer' STEM subjects – such as psychology and sports science.

Most STEM graduates never work in HS STEM jobs and even in subject areas such as engineering, that are most successful in this respect, fewer than two-thirds of employed graduates work in HS STEM positions. Some STEM subjects, biology in particular, have very poor records of supplying HS STEM workers. STEM graduates are no more likely to enter graduate positions than other graduates and graduates from post-1992 institutions have much worse prospects, in terms of HS STEM employment, than those from older universities. There is also evidence of attrition away from HS STEM roles, something that is not apparent in other areas of employment such as education and health.

The findings presented here, based on four very high quality data sets that are the best currently available, show none of the patterns that might be expected if there was an overall shortage of STEM graduates. Even in 'shortage' areas such as engineering and computer sciences, the relatively high levels of unemployment shortly after graduation, the large proportions of graduates working outside of the STEM sector, and the gradual attrition out of HS STEM roles, appear more consistent with a sector that is either unattractive to many potential employees or very selective about those deemed competent to work in it.

The implications of these findings, alongside some possible recommendations, are presented in the next section.

Implications and recommendations

Six of our main findings are set out here, along with their main implications for both employers in the STEM sector and for education policy and practice.

Finding 1:
Only a minority of STEM graduates enter HS STEM occupations, even in 'shortage' areas.

Implications for employers in the STEM sector

- As employers recruit only a minority of STEM graduates for HS STEM roles, there are large numbers of STEM graduates that could potentially work in HS STEM roles, many with degrees in 'shortage' areas or related disciplines.
- Compared to STEM graduates in general, an even smaller proportion of STEM graduates from certain groups, such as women and those who studied at post-92 universities, go on to work in HS STEM roles. These groups represent a particularly important source of potential recruits.
- There are many possible reasons why the majority of STEM graduates do not work in HS STEM roles. However, other sectors – in both the public and private sector – do not have similar problems with the recruitment and retention of suitable graduates, despite employing much higher proportions of graduates. Examining the recruitment practices, and understanding the motivations of graduate employees, in these sectors may help to attract more graduates to the STEM sector.

Implications for education policy and practice

- Simply increasing the number of students in the 'STEM pipeline' is unlikely to be an efficient way of providing employers with the graduate employees they want. This is particularly the case in relation to some STEM subjects, such as the biological sciences, that provide a very small proportion of the HS STEM workforce.

Finding 2:
The three key STEM shortage occupations (science, engineering and ICT professionals) attract only a small minority of STEM graduates. The highest recruiting occupational groups are teaching and functional management.

Implications for employers in the STEM sector

- STEM graduates are either being attracted to other occupations areas or failing to find work in HS STEM roles. The majority are not going into highly paid sectors such are banking and finance but into areas such as education and into lower-level management positions. Employment in STEM shortage areas is either unattractive or unobtainable for the majority of STEM graduates.

Implications for education policy and practice

- A greater awareness of the types of jobs that STEM graduates are actually employed in may help increase the number of students choosing to study science, particularly from traditionally under-represented groups.
- Even though teaching is the most common occupational destination for STEM graduates, many degrees cover little in the way of subject-based pedagogy. This is particular important given that the recruitment of science teachers has traditionally been difficult.

Finding 3:
A substantial proportion of STEM graduates move out of HS STEM roles as their careers progress but few older workers move into HS STEM positions.

Implications for employers in the STEM sector

- Retaining current graduate employees in HS STEM positions could help reduce the number of vacancies needing to be filled by recent graduates.

- Attracting older STEM graduates into the sector for the first time could help fill current vacancies. Older non-STEM graduates and non-graduates could also be sources of new recruits.

Implications for education policy and practice

- There may be a market for postgraduate qualifications aimed at 'refreshing' the knowledge and skills of older STEM graduates who have not previously worked in HS STEM positions.

- Retraining non-STEM graduates, and non-graduates, for new careers in HS STEM roles, is another potential avenue for the recruitment of HS STEM workers.

Finding 4:
The majority of HS STEM workers are non-graduates

Implications for employers in the STEM sector

- STEM degrees, or graduate-level education in any subject area, are not a pre-requisite for employment in all HS STEM jobs, even if they are considered desirable.

- Looking beyond STEM graduates in allied fields – to other STEM graduates, non-STEM graduates, and non-graduates – could help reduce the number of unfilled posts.

Implications for education policy and practice

- The emphasis on participation in higher education in recent decades may be over-shadowing other routes into HS STEM jobs, such as apprenticeships.

Implications and recommendations

Finding 5:

There are large differences in the proportion of different groups of STEM graduates entering HS STEM jobs. Much smaller proportions of graduates in some STEM subjects, from some types of university, and from different social groups, enter HS STEM occupations than others.

Implications for employers in the STEM sector

- Particular groups of STEM graduates, in particular biological science graduates and those graduating from post-1992 institutions, are currently under-represented in the HS STEM workforce and could be a valuable source of potential employees if targeted effectively.

- The differential participation in HS STEM careers of graduates from post-1992 institutions is striking and may reflect a gap between the skills and knowledge of the students graduating from these institutions and the requirements or expectations of employers.

Implications for education policy and practice

- The chances of working in HS STEM jobs varies considerably between groups from different social and educational backgrounds. This has implications for the careers advice given to students at all stages of education and training.

- Encouraging currently under-represented groups to pursue STEM degrees may be problematic. The evidence suggests that those STEM graduates from under-represented groups are less likely to work in HS STEM positions.

- The possible gap between the skills and knowledge of the students graduating from some institutions and the requirements of employers may have implications for the design of curricula and the role of employers in providing additional education and training.

Finding 6:

There is little variation between the immediate and longer-term occupational destinations of STEM and non-STEM graduates in terms of graduate-level employment.

Implications for employers in the STEM sector

- The vast majority of graduates are employed in graduate-level positions by the end of their twenties. STEM employers are competing for workers in a context in which most graduates are able to find high status, professional-level work. The salaries and working conditions they offer must reflect this if they are to remain competitive.

Implications for education policy and practice

- Encouraging students to study STEM degrees on the basis of better labour market outcomes is ethically questionable. STEM graduates have little advantage over non-STEM graduates in terms of securing graduate-level employment and most STEM graduates never work in HS STEM jobs.

Recommendations for employers and educational policy and practice

Recommendations for employers in STEM fields

- Consider lowering expectations of the fit between the knowledge and skills possessed by recent graduates and the particular requirements of the positions needing to be filled.
- Expect to provide more on-the-job training for newly recruited graduates.
- Recruit a larger proportion of employees from a wider range of educational backgrounds, including STEM graduates from other disciplines, non-STEM graduates and non-graduates.
- Target STEM graduates from groups that are under-represented in their workforces, such as women and graduates with degrees from 'new' universities.
- Work more closely with post-1992 higher education institutions to develop curricula and provide occupational guidance for students.
- Learn from the recruitment practices of other sectors, such as banking and finance, that demand high quality graduates but do not report labour shortages.
- Consider attracting graduates by changing the pay and conditions currently offered.
- Provide incentives for experienced HS STEM workers to remain in technical roles rather than moving into management positions.

Recommendations for educational policy and practice

- Encourage students to consider non-graduate routes into HS STEM careers.
- Provide information to students about the proportion of STEM graduates entering and remaining in HS STEM professions and how this varies according to degree subject, type of higher education institution and social background.
- Explore the market for postgraduate and non-graduate-level courses to prepare older workers for HS STEM jobs.
- Communicate more closely with employers to improve the employability of graduates and to manage employers' expectations about job 'readiness'.

Further Information

Further information and more detailed analysis can be found on the project website and in the following initial publications:

Smith, E. & White, P. (2018), Where do all the STEM graduates go? Higher education, the labour market and career trajectories in the UK, *Journal of Science Education and Technology,* DOI: 10.1007/s10956-018-9741-5.

Smith, E. (2017), Shortage or surplus? A long-term perspective on the supply of scientists and engineers in the US and the UK, *Review of Education.* 5(2), 171-199.

White, P. & Smith E., (2016), Taking the long view, *Physics World*, October 2016, www.physicsworld.com

Smith, E. & White, P. (2016), A 'great way to get on'? The early career destinations of science, technology, engineering and mathematics graduates, *Research Papers in Education,* 32(2), 231-253.

Smith, E. (2016), Can higher education compensate for society? Modelling the determinants of academic success at university, *British Journal of Sociology of Education,* 37(7), 970-992.

Smith, E. (2014), Does the UK really need more engineers? *Times Higher Education Supplement*, 6th March 2014.

Smith, E., (2011), Women into Science and Engineering? Gendered patterns of participation in UK STEM subjects, *British Educational Research Journal*, 37(6), 993-1014.

Smith, E., White, P., (2011), Who is studying science? The impact of widening participation policies on the social composition of UK undergraduate science programmes, *Journal of Education Policy*, 26(5), 677-699.

Smith, E. & Gorard, S. (2011), Is there a shortage of scientists? A re-analysis of supply for the UK, *British Journal of Educational Studies*, 59(2), 159-177.

Smith, E., (2010), Do we need more scientists? A long term view of patterns of participation in UK Undergraduate Science Programmes, *Cambridge Journal of Education,* 40(3), 281-298.

References

1. Bush, V., (1945), Science the Endless Frontier, A Report to the President, Washington DC: US Government Printing Office.

2. President Barack Obama, Speech to the National Academy of Sciences, 2009.

3. BB. (2014), 'Skills Shortages Holding Back the UK's Economic Recovery', BBC Online, www.bbc.com/news/business-30224320; The Telegraph. (2013), ' Shortage of Engineers is Hurting Britain, Says James Dyson,' September 5, 2013, www.telegraph.co.uk/finance /newsbysector /industry/engineering/10287555/ Shortage-of-engineers-is-hurting-Britainsays-James-Dyson.html.

4. CBI (2014), Gateway to growth, CBI/Pearson education and skills survey 2013, London: CBI; Select Committee on Science and Technology (2012), Higher Education in Science, Technology, Engineering and Mathematics (STEM) subjects Report, House of Lords Select Committee on Science and Technology, London: The Stationery Office Limited.

5. CIHE; CBI (2014a), Engineering our future: Stepping up the urgency on STEM, London: Confederation for British Industry; Cm 8980, (2014), Our plan for growth: science and innovation, HM Treasury and Department for Business, Innovation and Skills, London: HM Treasury; Wakeham Review (2016), Wakeham Review of STEM Degree Provision and Graduate Employability, https://www.gov.uk/government/publications/stem-degree-provision-and-graduate-employability-wakeham-review

6. Teitelbaum, M.S., (2014), Falling Behind? Boom, Bust and the Global Race for Scientific Talent, Princeton: Princeton University Press

7. Smith, E., Gorard, S. (2011), Is there a shortage of scientists? A re-analysis of supply for the UK, British Journal of Educational Studies, 59(2), 159-177; UKCES (2011), The supply of and demand for high- level STEM skills, UK Commission for Employment and Skills: Briefing paper, December 2011, www.ukces.org.uk/assets/ukces/docs/publications/briefing-paper-the-supply-of-and-demand-for-high-level-stem-skills.pdf, Teitelbaum (2014).

8. Select Committee on Science and Technology (2012).

9. Smith, E., (2017 in press), Shortage or surplus? A long-term perspective on the supply of scientists and engineers in the US and the UK, Review of Education, DOI: 10.1002/rev3.3091

Appendix A – Data used in the study

The empirical phase of this study has relied exclusively on the secondary analysis of existing data. We used data from the two oldest birth cohort studies (the 1958 National Child Development Study (NCDS) and the 1970 British Cohort Study (BCS70)), survey data from the the Annual Population Survey (APS) and administrative data gathered by the Higher Education Statistical Agency (HESA). These represent the best publically available data on the participation of graduates in the STEM workforce. Further discussion about the data used in the study can be found on the project website.

HESA First Destination Survey

Aggregate population data retrieved from HESA were used to investigate the activities of more than 3 million first-degree graduates from STEM and non-STEM programmes at UK universities. The data span a seventeen-year period (from 1994 to 2011) and allow detailed coverage of trends in different subject areas (both STEM and non-STEM). The data are collected through questionnaires sent out to their graduates by higher education institutions that ask about activities undertaken within six months of graduation. In this study, first destination data has been examined from the academic year 1994/5 (the earliest date for which such data were available) to 2010/11. Although at the time of writing data for the academic years beyond 2010/11 were available for analysis, HESA had changed the definitions of a number of key categories and therefore 2010/11 is the last year for which comparable data exists. In 2002, HESA moved from using the SOC1990 occupational classification to SOC2000. Data prior to 2002 is not comparable and so for occupational groups the analysis begins with graduates from the 2002/3 academic year. For further information on how this dataset was used in the study see Smith and White (2016).

Institutional differences in the early destination data

We also compare the characteristics and early career destinations of STEM graduates from two different types of institution. There are currently around 160 institutions of higher education in the UK, the vast majority of which are state funded. The number of universities has changed over the period studied here, as some colleges of higher education have gained university status, other institutions have merged, and new institutions have been created. For the purpose of comparison, we rely on existing groupings of universities that are widely used in the sector. As it is not unusual for different institutions to change their membership of these groups, this analysis was based on those institutions that were members of the Russell Group, University Alliance, and Million+ group in the summer of 2015. All analysis is based on these categories. The grouping of institutions in this way represents a useful way of comparing the characteristics of what are often termed 'elite' British Universities (in other words the Russell Group) with a group of former polytechnics (the University Alliance and Million+ group).

The Annual Population Survey

The APS is a major national cross-sectional survey, which covers topics such as education, health and ethnicity, as well as including key variables from the Labour Force Survey. The survey first took place in 2004 and data for four years were analysed in this study. However, as the findings of our analysis for each APS year were very similar, data for all four years were combined for the analysis presented here. In order to enable comparison with the cohort studies and also examine patterns of participation among older workers, we used data for 25 to 64 year-olds

Table A1: Selected characteristics of the APS members (aged 25-64)

Year	Total sample (N)	Female		White (British)		First degree		Stem degree	
		N	%	N	%	N	%	N	%
2004	270135	141772	53	243528	90	27409	18	10094	4
2006	186064	98184	53	162188	87	34562	19	13111	7
2008	178160	94042	53	152996	86	36430	21	13857	8
2010	169275	89219	53	141403	85	38114	22	14604	9
All	803634	423217	53	700115	87	136515	20	51666	6

The 1970 British Cohort Study

The 1970 British Cohort Study (BCS70) follows the lives of around 17,000 individuals who were born in Great Britain in one week in April 1970 and who are now aged in their mid-40s. Data from five sweeps of the study were used in this analysis and provide a detailed account of the cohort members' career trajectories at ages 26, 30, 34, 38 and 42 (Table A2).

Table A2: Sample size and response rates for BCS70 members

Age of cohort	Year of sweep	Number of participants	Response rate (%)
26	1996	9003	56
30	2000	11261	70
34	2004	9665	75
38	2008	8874	76
42	2012	9841	75

Appendix A – Data used in the study

Although the original sample size for the cohort studies was relatively large (in the region of 17,000 individuals were first contacted to participate), the number of active members has fallen over time, leaving a useable sample of about 10,000 individuals. The focus in this project on graduates, STEM graduates, and subject specific variation, means that at lower levels of aggregation the group sizes become smaller and more volatile. Because of this, some of the findings in this report have been expressed with caution.

The data were analysed in three different ways. Each sweep of the cohort studies was analysed separately. All respondents providing relevant data in that sweep were included in the analyses. Analyses were also conducted using only those respondents who provided occupational data for every sweep. The findings were similar but these results are not presented here because of the very small cell sizes that resulted from the smaller number of cases that could be included. Lastly, occupational mobility was analysed, including, where appropriate, only those respondents including occupational data for either consecutive sweeps or across the study as a whole.

The National Child Development Study

The National Child Development Study (NCDS) is an ongoing longitudinal study that follows the lives of a cohort of individuals who were born in March 1958. To date there have been nine 'sweeps' of the NCDS, with the latest sweep taking place in 2012/13, when participants were 54 years old. We analysed data at six points, from 1981 to 2012/13, (see Table A3) which capture the first employment destinations of the NCDS graduates as well as career patterns in the intervening decades. As most of the findings for the BCS70 were replicated in the NCDS (as well as for reasons of space) this final report emphasises the results from the former study. Findings from the NCDS can be retrieved from the project website.

Table A3: Sample size and response rates for the 1958 NCDS members

Age of cohort	Year of sweep	Sample size	Response rate (%)
23	1981	11107	72
33	1991	11044	72
42	2000	11044	72
46	2004	9230	60
50	2008	9464	62
54	2012	8647	58

Appendix 2 – Defining key terms

STEM subjects

Defining STEM subjects can be problematic and some broad definitions include subjects with relatively little scientific content. In the absence of a consensus we have adopted the nine categories that are used by the UK universities admissions authority (UCAS):

- Medicine and Dentistry
- Subjects Allied to Medicine
- Biological Sciences
- Veterinary Sciences, Agriculture and related
- Physical Sciences
- Mathematical Sciences
- Computational Sciences
- Engineering and Technologies Sciences
- Architecture, Building and Planning

In this study we focus on the five main STEM subject groups listed below, along with their main constituent subjects. We have paid particular attention to HEFCE's strategically important and vulnerable subjects (SIVs) that are highlighted in bold in the list below:

- Biological Sciences: including biology, sports science, and psychology.
- Physical Sciences: including **chemistry, physics,** and physical geographical sciences.
- Mathematical Sciences: including **mathematics.**
- Computing Sciences: including computer science.
- **Engineering** and **Technology** sciences: including civil, mechanical, electronic and electrical engineering.

The SOC 2000 occupational class schemas

Where possible, all occupational data is categorised according the nine SOC2000 occupational classifications (listed below). The Standard Occupation Classification (SOC) is the common classification for occupational data in the UK. The SOC2000 replaced the SOC90 and has itself now been updated by the SOC2010. Most of the data used in this study were originally coded using the SOC2000 schema; therefore this classification has been retained for analysis and reporting of trends.

- SOC Group 1 Managers and Senior Officials
- SOC Group 2 Professional Occupations
- SOC Group 3 Associate Professional and Technical Occupations
- SOC Group 4 Administrative and Secretarial Occupations
- SOC Group 5 Skilled Trades Occupations
- SOC Group 6 Caring Personal Service Occupations
- SOC Group 7 Sales and Customer Service Occupations
- SOC Group 8 Process, Plant and Machine Operatives
- SOC Group 9 Elementary Occupations

Occupations within these nine major categories are represented by 2, 3 and 4 digit codes that represent increased levels of discrimination between different roles. A mixture of 1, 3 and 4 digit codes were used in this study.

Definitions of graduate occupations

As participation in higher education has increased, so has the range of what might be considered to be graduate jobs. To help address this issue Elias and Purcell7 propose a five-category classification of graduate destinations:

'Traditional': Established professions requiring degrees, such as solicitors, secondary school teachers and chemists.

'Modern': Newer professions that graduates have entered since university expansion in the 1960s, such as computer programmers and journalists.

'New': New or expanding areas where the route into the professional area has recently changed so that it is now via an undergraduate degree, for example: physiotherapists and probation officers.

'Niche': Occupations where the majority of post holders are not graduates, but where there are stable or growing specialist niches which require higher education skills. For example: nurses, retail managers.

'Non graduate': Occupations that do not fall into any of the above categories.

Appendix 2 – Defining key terms

The key distinction for many of our analyses in this study is that between graduate and non-graduate destinations. The first of Elias and Purcell's four categories – 'traditional', 'modern', 'new' and 'niche – constitute graduate employment and the fifth, non-graduate employment. Using this classification, graduate employment is defined as most occupations that fall into SOC categories 1-3 (Managerial, Associate/Professional and Technical); while non-graduate employment largely comprises SOC categories 4-9 (Administrative and Secretarial, Personal Service, Sales and Customer Service, Machine Operatives and Elementary Occupations). A full list of occupational categories and their link to (non) graduate employment can be found in Elias and Purcell.[7]

Defining HS STEM occupations

Deciding whether or not a graduate is employed in a HS STEM sector job is problematic and sometimes arbitrary. With this caveat in mind, we have adopted the classification used by the United Kingdom Commission for Education and Skills (UKCES) which uses the criteria of whether an occupation has a high proportion of graduates, a high proportion of STEM-degree holders and a high proportion of STEM-degree holders among graduate entrants. The list below shows the UKCES classification of HS STEM jobs and the corresponding UK Standard Occupation Classification (SOC) 2000 3-digit occupational codes.

SOC code	HS STEM occupations
112	Production Managers
121	Managers in Farming, Horticulture, Forestry and Fishing
211	Science Professionals
212	Engineering Professionals
213	Information and Communication Technology Professionals
221	Health Professionals
232	Research Professionals
242	Business and Statistical Professionals
243	Architects, Town Planners, Surveyors
311	Science and Engineering Technicians
312	Draughtspersons and Building Inspectors
313	IT Service Delivery Occupations
351	Transport Associate Professionals
353	Business and Finance Associate Professionals
355	Conservation Associate Professionals

The following indicates the occupations that were included in Bosworth et al.'s (2013) definition of HS STEM jobs.

SOC code	HS STEM occupations
112	Production Managers
113	Functional Managers
118	Managers in farming etc.
211	Science Professionals
212	Engineering Professionals
213	Information and Communication Technology Professionals
221	Health Professionals
231	Teaching Professionals
232	Research Professionals
243	Architects, Town Planners, Surveyors
311	Science and Engineering Technicians
312	Draughtspersons and Building Inspectors
321	Associate Health Professionals
322	Therapists
355	Conservation Associate Professionals

Notes

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School of Media,
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Bankfield House, 132 New Walk,
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t: +44 (0)116 223 1450
e: pkw4@le.ac.uk
w: www.le.ac.uk

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