Reviewing the requirement for high level STEM skills

UK COMMISSION FOR EMPLOYMENT AND SKILLS

Contents

This publication contains analysis of the Quarterly Labour Force Survey and the Labour Force Survey Five-Quarter Longitudinal Dataset, both produced by the Office for National Statistics (ONS), under Crown Copyright.

Additional analysis has used the Skills and Employment Survey 1986-2012 dataset produced by Felstead, Gallie and Green with funding most recently from the Economic and Social Research Council, the UK Commission for Employment and Skills, and the Wales Institute of Social and Economic Research, Data and Methods.

These data sources were accessed under licence, through the UK Data Archive http://ukdataservice.ac.uk/

Additional analysis of ONS statistical data, again Crown Copyright, were accessed through the Nomis service at the University of Durham http://www.nomisweb.co.uk/

The analysis also draws heavily on the UK Commission for Employment and Skills' Working Futures 2012-2022 projections, with detailed analysis accessible at https://www.gov.uk/government/collections/the-future-of-jobs-and-skills

Data visualisation used R 3.1.2 with packages including ggplot2 and ggthemes.

Introduction

In *Growth Through People*, the UK Commission for Employment and Skills called for a greater range of options combining work and study to deliver the higher level technical education needed to meet the UK's skills needs. This agenda is particularly relevant to STEM skills, which are critical to UK competitiveness but also subject to significant shortages in some instances. This document summarises a review conducted by the UK Commission to assess high level STEM occupations according to labour market need, in order to inform the development of work-based skills solutions, including higher apprenticeships. It identifies those occupations which have a strong requirement for high level STEM skills, examines the labour market need associated with them, and considers priorities for the future development of work-based provision.

To reshape its economy around high value, knowledge-intensive activities within an increasingly competitive global economy, the UK must meet the growing demand for people equipped with higher level, economically valuable skills. In particular, ensuring that businesses have access to science, technology, engineering and mathematics skills is critically important since these skills play a central role in developing innovative products and services that can be effectively positioned in world markets.

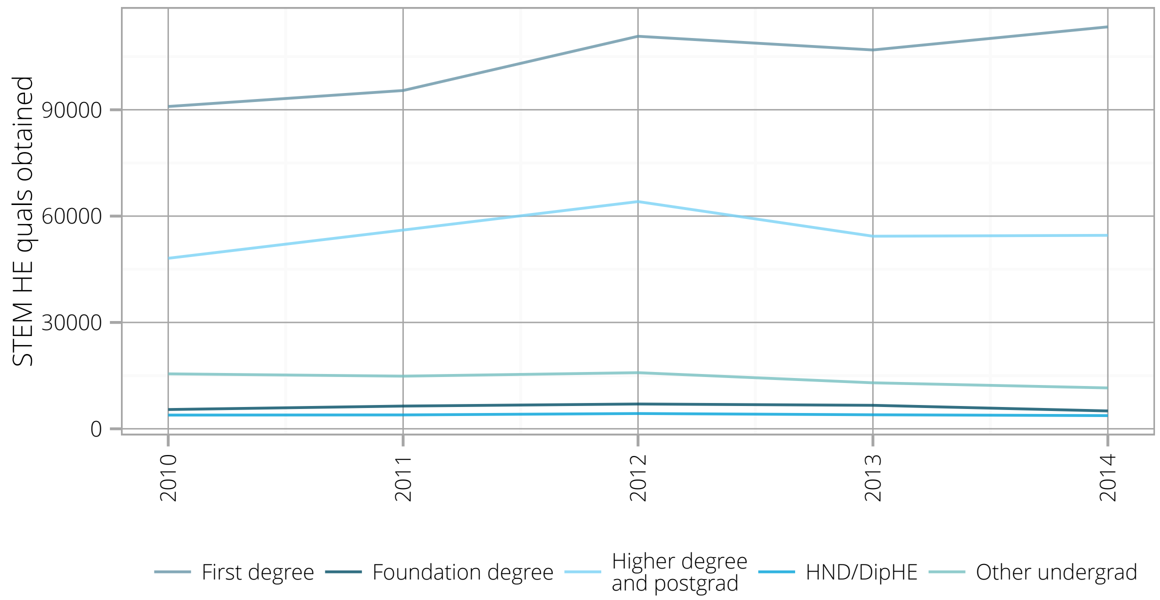
As part of its response to the higher level skills challenge, the Government is committed to a programme of higher apprenticeships that combine on the job training with study for a higher level qualification at level 4 or above. They are seen to be a mechanism by which employers can more effectively access the specific skills that they need, by growing their own talent and developing a loyal and motivated workforce. At the same time, employers are working together through Industrial Partnerships and other mechanisms to develop further skills solutions to address their high level needs.

In support of this the Government has asked the UK Commission for Employment and Skills to conduct a review of STEM skills to advise on the STEM occupations that face the greatest labour market need, in order to inform decisions around the future development of this kind of provision in the STEM sphere.[1] As a provider of high quality business and labour market intelligence designed to inform choice, policy and practice, the UK Commission is well placed to undertake this task.

This report is primarily intended to inform the thinking of employers as they consider the strategic skills solutions needed by their respective sectors and occupations. It is also a resource for policy makers as they seek to support and enable employer-led strategies, particularly in areas of market failure. It is very much a top-down analysis, based on common and consistent sources of labour market data and is intended to provide a framework for more detailed research and analysis from the bottom-up by Industrial Partnerships and other employer-led bodies.

1 The full review findings are presented in a more detailed Evidence Report.

Figure 1 HE qualifications in STEM subjects obtained in the UK by level of study



Source: Higher Education Statistics Agency. See accompanying Evidence Report for definition of STEM subjects; we exclude medicine and veterinary subjects in this data.

Why action on STEM skills is important

The UK's economic future lies in high value, innovative and knowledge-intensive activities. To pursue this course a highly skilled science, technology, engineering and mathematics workforce is essential.

Numbers of STEM graduates are strongly correlated with innovation and not just for traditional STEM enterprises. Around 45 per cent of graduates working in innovative firms in manufacturing and knowledge-intensive business service industries had a degree in a STEM subject, compared to only about 30 per cent of graduates in non-innovative firms.[2]

Figure 2 shows that there is an association between hourly pay and the use of STEM skills in the workplace, suggesting that these skills are a factor in increased earnings and productivity.

International benchmarking, suggests that the UK's science and innovation system is hampered by weaknesses in its STEM talent base. As well as low basic skills (numeracy, literacy, ICT) and below-average management skills, there is insufficient domestic human capital to exploit science and innovation, including deficits of domestic STEM talent and of Masters/PhD graduates working in research.[3]

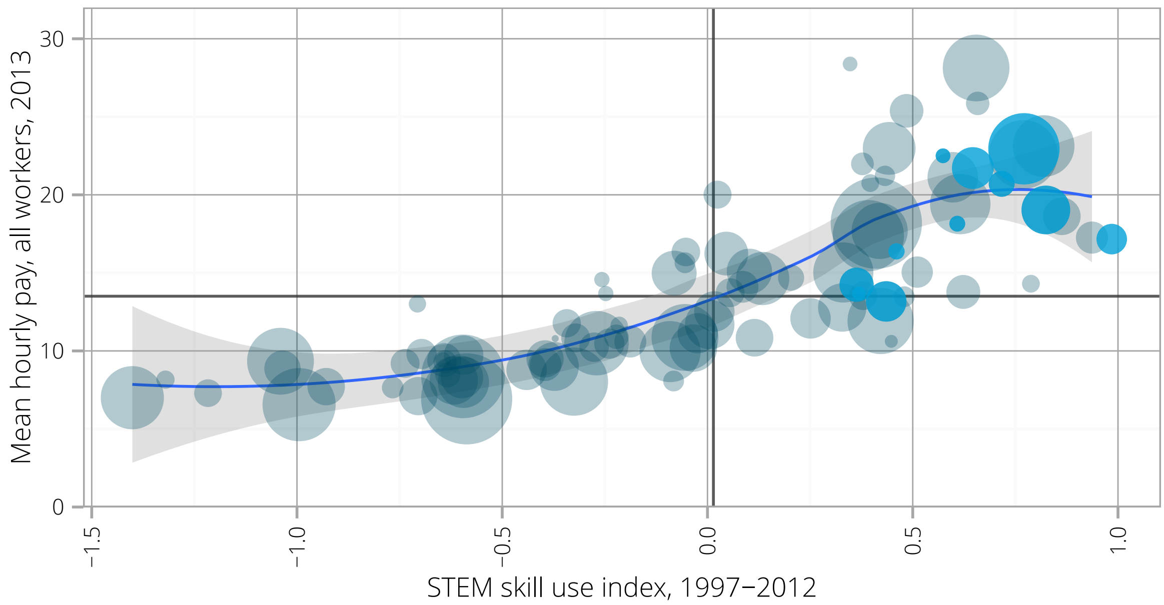
This is supported by the evidence that employers cannot get the skills that they need. According to the UK Commission's Employer Skills Survey 2013,[4] 43 per cent of vacancies for professionals working in science, research, engineering and technology are hard to fill due to skills shortages. This is almost twice the average for all occupations, making it the worst affected of all 25 occupational sub-major groups within the Standard Occupational Classification.

2 Levy and Hopkins (2010).

3 BIS (2014).

4 UKCES research by Winterbotham et al. (2014).

Figure 2 STEM skills use and hourly pay (SOC minor groups and STEM job families)



Source: Labour Force Survey and UK Skills and Employment Surveys. Blue bubbles are 'STEM job families' identified from the analysis presented in the accompanying Evidece Report.

The results from previous iterations of the survey suggest a persistent problem, pre-dating the recession. Moreover, the reported shortages are primarily due to a deficit of technical, practical or job specific skills.

With regard to supply, the number of higher education qualification achievements in STEM subjects has increased significantly in recent years (see figure 1), although this growth has been concentrated in first degree qualifications rather than more vocationally-oriented qualification types such as foundation degrees. The current level of take-up of STEM-related Higher Apprenticeships is very modest overall.

On balance, the wider evidence presented in the main report suggests that there is no overall undersupply in the labour market of individuals with high level STEM skills. Rather, the issue seems to be one of concentrated pockets of shortages, where employers report insuffcent potential recruits with specific skills.

Qualitative evidence suggests that reasons for this include a lack of degree courses with the right technical content, few well-rounded candidates with practical experience and broader competencies, such as mathematical capability.

There is also evidence to suggest that high level STEM workers are often less likely to receive training than their counterparts in other roles. Training among science, engineering and technology professionals is lower than for other professional occupations. This suggests that employers may need to raise their investment in developing the skills of workers in these roles.

There is also a geographic dimension to the shortages.[5] London appears to be a magnet for inward commuters with high level STEM skills, creating difficulties for employers in neighbouring regions. It is in this context, that higher apprenticeships' work-based routes are intended to enable employers to access the specific skills that they need by developing their own talent.

5 UKCES research by Bosworth (2013).

Demand drivers

Headlines

- A series of fundamental trends are shaping the global economy and the future of work.
- Trends such as the digitalisation of production and the age of Big Data are transforming STEM jobs and skills.

The UK Commission's recent *Future of Work* study analyses the trends which are shaping UK jobs and skills.[6] The study adopted a 360° view; looking at societal, technological, economic, ecological and political factors (Figure 3) to identify and focus on the 13 most influential and plausible trends impacting the jobs and skills landscape in the UK to 2030.

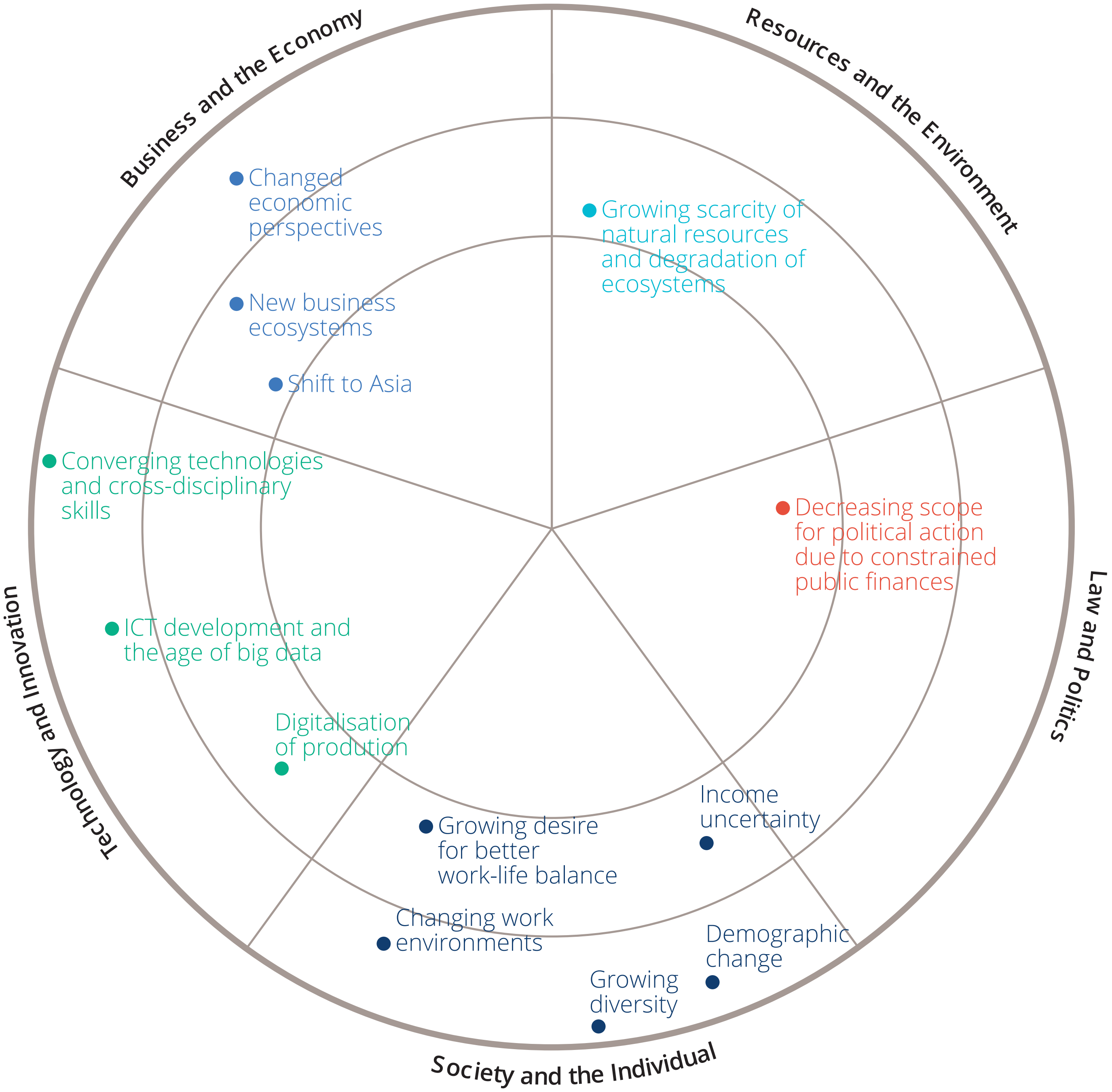
Many of these trends have strong relevance for high level STEM skills; in terms of raising the demand for these skills, shaping the nature of skill requirements and influencing the way in which they are applied. In Figure 4, a selection of these trends are examined in more detail and examples of their implications for STEM skills are highlighted.

As this analysis shows STEM skills are being shaped by the fundamental trends that are shaping the global economy and also the future of work. These disciplines also act as key enablers of some trends, such as the digitalisation of production.

6 UKCES research by Störmer et al (2014).

Figure 3 Trends driving the future of UK jobs and skills

Which occupations have a significant requirement for STEM knowledge and skills?



Source: UKCES research by Störmer et al, 2014.

Trend	Description
Converging technologies and cross-disciplinary skills	The boundaries between disciplines, such as natural sciences and informatics, are becoming increasingly blurred. As disciplines converge, so do the technologies. This can disrupt existing business models, but also creates completely new markets and novel application fields.
Digitalisation of production	As digitalisation becomes pervasive in production, autonomous, decentralised and local production systems and factories are within reach, ushering in a new era of industrialisation.
ICT development and the age of 'Big Data'	The amount of data generated by the digital economy is growing rapidly. Analysing this data offers tremendous potential for efficiency gains and new business models and opportunities.
Shift to Asia	Economic power is shifting towards emerging countries. This may mean further off-shoring and outsourcing of jobs for the UK. It will certainly mean more intense international competition for its businesses.
New business ecosystems	A new organisational paradigm sees companies increasingly defined as 'network orchestrators'. The skills and resources they can connect to, through activities like crowdsourcing, become more important than the skills and resources they own.
Growing scarcity of natural resources and degradation of ecosystems	Global economic growth is leading to a growing worldwide demand for natural resources and raw materials. Over exploitation implies higher extraction costs and degradation of ecosystems. Environmental regulation is creating new demand for low-carbon technologies and resource efficiency.
Changing work environments	Businesses are able to create and disband divisions rapidly, as they shift tasks between slimmed-down pools of long-term core employees, international colleagues and outsourced external service providers. Jobs and organisations are becoming increasingly flexible in response to the shift towards a 24 hour society

Source: UKCES research by Störmer et al, 2014.

Figure 4 Selected trends shaping the future of UK jobs and skills: implications for STEM

	Examples of STEM skills implications
	A key implication of this trend is that high skilled workers with a background in STEM increasingly need to work in multi-disciplinary teams to address business objectives. For example, bioinformatics is a rapidly growing inter-disciplinary scientific field which seeks to develop methods and software to understand biological data using techniques and concepts drawn from informatics, statistics, mathematics, chemistry, biochemistry, physics, and linguistics.
	The digitalisation of production increases the demand for engineers specialised in cyber-physical systems both for the development and the implementation of high-tech manufacturing. The higher level of technology integration requires employees to have relevant skills, including skills in design, simulation and data analytics. There is likely to be continued need for (up-skilled) technicians to manage automated production systems.
	High demand is expected for data management, analysis and visualisation skills as the amount of data transferred, collected, and stored increases exponentially. In particular, knowing how to turn data into insights that increase the efficiency of existing business and generate ideas for new business opportunities will be highly valued. There is also likely to be an increasing need for those with cyber security and digital forensic skills.
	The manufacturing sector in the UK will be challenged to upgrade its innovation capacity in response to global competition. This is likely to mean a continued transformation of manufacturing to a highly sophisticated industrial sector where high-skilled engineers are increasingly in demand.
	Under these emerging business models processes of so-called open innovation become more important. For STEM workers who are core to the innovation process, teamwork in virtual teams, across businesses, functions and organisations, will grow in importance.
	An increased focus on reducing carbon emissions and energy consumption will lead to growing demand for skills in material and resource efficiency, particularly in engineering and design, but also in most occupations across all sectors
	Engineers have seen a move from working on-site to working remotely. This translates the physical world into a digital one, and allows engineers to operate in a virtual environment. For example, in the case of equipment on oil platforms, due to remote control an engineer is often not required to go to the site when a problem occurs, because it can be fixed remotely with less downtime.

STEM in the workplace

Headlines

- STEM skills are critical to the most dynamic sectors in the economy in knowledge-based services and manufacturing.
- They are crucial to the development of the priority sectors identified in the Government's industrial strategy
- STEM occupations play a key role in the workplace in terms of functions such as the development and optimisation of new products, processes and systems.

We have established the value of STEM skills in broad terms. But how, in specific terms, do they add value in the workplace? In the following section we seek to bring this to life with reference to sectoral and occupational dimensions. How do STEM skills add value to key industry sectors? How are STEM skills applied in the specific context of occupations and jobs?

Industry sectors

In his review of the supply and demand of STEM skills, Bosworth[7] seeks to use empirical methods to identify detailed industry sectors with a strong requirement for high level STEM skills. Industries with the strongest requirement for high level STEM skills include research and development in fast moving scientific disciplines; technical consultancy activities that are central to the performance of the production sector of the economy; activities that are core to the information economy, including computer programming; and niche manufacturing activities that draw on a high level of scientific knowledge.

A further illustration of the role of STEM skills is provided by the Government's industrial strategy sectors. These are sectors that have been identified on the basis of their potential to contribute to future economic growth and employment and in which government action could add most value.

The majority, if not all, of these sectors are characterised by a strong reliance on high level STEM skills. Detailed examination of the strategy documents provides an insight into how important these skills are to the performance of the sectors and how key business drivers are shaping the nature of demand for these skills, as well as opening up potential areas of skills mismatch and shortage. The three case studies illustrate this with reference to three industrial strategy sectors: agri-tech, aerospace and the information economy.

Among the 11 sectors prioritised in the Government's industrial strategy several can be described as fundamentally science-led. Life sciences is defined by the application of biology.[8] The sector needs highly skilled researchers, clinicians and technicians, working together collaboratively, if new discoveries in fields such as regenerative medicine, antibody therapies and the application of robotic surgery technology are to be capitalised upon.[9] Agri-tech is another science-based sector, profiled in the case study

7 UKCES research by Bosworth (2013).

8 Life sciences includes medical devices, medical diagnostics and pharmaceuticals, through to synthetic and industrial biotechnology.

9 BIS (2011a).

Case study: the agri-tech sector

Agricultural science and technology represents one of the world's fastest growing markets, driven by fundamental global changes including population growth, the development of emerging economies with western lifestyle aspirations, as well as geopolitical instability around shortages of land, water and energy. At the same time agriculture is being transformed by a technological revolution based on breakthroughs in nutrition, genetics, informatics, satellite imaging, remote sensing, meteorology, precision farming and low impact agriculture.

A strong scientific capability is needed to support the agri-food supply chain, which plays a crucial part in the UK economy, making an estimated contribution of £96 billion or 7 per cent of gross value added and employing 3.8 million people.

The skills needed to support the sector are changing rapidly, moving towards technology and higher level scientific and managerial skills to match advances in informatics, precision farming and engineering. Breakthroughs in scientific knowledge require a focus on detailed biology but this needs to be coupled with the skills required to turn basic science into improved agricultural practice.

There is an increasing emphasis on an interdisciplinary approach. There is a need to bring together agronomy and automation, to develop production systems that are less dependent on human labour and interventions. The application of mathematics and computing are essential to biology for the decoding of plant, animal and microbial genomes.

The sector has identifed a future risk of higher skills shortages in 'niche' areas where there are currently only a handful of experts in the UK, such as agronomy, plant pathology and agricultural engineering.

Source: BIS, 2013.

Case study: the aerospace sector

UK aerospace manufacturing is second only to the United States. UK firms produce the most valuable elements of today's airliners including the wings, engines, and advanced systems. The sector has more than 3,000 companies, employs around 230,000 people and generates over £24 billion in annual revenues.

The sector has excellent growth prospects, driven by a forecast doubling in air traffic in the next 15 years. However, as new manufacturers of civil aircraft enter the marketplace across the world UK companies at all levels of the supply chain will need to diversify their customer base.

Aerospace spends some £1.4 billion on R&D. Pressures to reduce costs and environmental impacts are driving substantial changes. For example, new materials such as composites are increasing in use, but the challenge is in exploiting their properties by applying radical new design options and optimising manufacturing processes to deliver economically.

To compete with low-cost global manufacturing centres UK aerospace need to be more innovative in the application of materials, production equipment and processes. They also need to optimise transport and logistics networks to secure efficiencies in the flow of materials and components. These kinds of innovation require world-class production knowledge.

Aerospace depends on a strong pipeline of skills, requiring the development of higher level skills in technologies and manufacturing processes across a range of disciplines, including materials science, system engineering, robotics and automation, software and additive layer manufacturing.

The industry faces skill shortages in fatigue and damage tolerance, composites, stress and licensed engineers. Some firms have found particular difficulty in recruiting technicians skilled in working with composite materials, which require different skill sets to those trained and experienced in metallics.

Source: BIS, 2013a.

Case study: information economy

The revolution in information and communications technology is transforming the way we live and work. The information economy is changing the way we deliver education and business services, design buildings and cities, and manufacture engines and cars.

Business sectors across the economy are being transformed by data, analytics, and modelling. As a result of high performance computing, cloud computing and open data initiatives data is increasingly being produced at a rate that means that current techniques are insufficient to fully exploit it. 90 per cent of the data in the world today was created in the last two years alone. Nonetheless we are seeing rapid advances in mathematical science and algorithms.

Examples of this transformative effect include virtual prototyping which has transformed manufacturing and design, or the insights into customer shopping habits gained by retailers.

At the same time city leaders across the world are turning to integrated "intelligent" or "smart" systems and concepts to deliver vital public services, such as smart energy grids, traffic and congestion management and waste management. The provision of smart solutions represents a significant global market opportunity and a means by which UK cities can address their own challenges.

It is in this context that there has been a rapid increase in demand for workers who have the skills to exploit Big Data, with the Tech Partnership pointing to a ten-fold increase in vacancies over a five year period. A variety of roles are required, including developers, architects, consultants, analysts and data scientists; with strong demand for technical skills including experience of big data, business intelligence, data warehousing and analytics.

Source: BIS, 2013b

Advanced manufacturing activities base their competitive advantage on constant innovation, developing new processes, products and solutions to solve problems and better meet customer needs. The UK automotive sector is the fourth largest vehicle producer in Europe, making 1.58 million vehicles in 2012. In order to get ahead of the game in research and development (R&D) on ultra-low emission vehicles, strengthen the UK automotive supply chain and meet increasing production demand the sector needs to address a shortage of engineers and other skilled workers.

STEM skills are also critical to the priority sectors which meet the UK's energy needs, including offshore wind, oil and gas and nuclear. In the nuclear sector a substantial programme of new build is expected together with an expansion of the global nuclear industry. In this context innovation and R&D in the supply chain is crucial for UK companies to increase competitiveness and secure contracts, as well as maintaining the highest standards of safety and driving down costs. This is creating strong demand for STEM skills at all levels. At the same time other parts of the energy sector face similar needs creating competition for the same skills and experienced people.

Occupations

High level STEM occupations make a practical contribution in a wide variety of ways to the operation and performance of businesses and the wider economy. Below we provide an illustrative overview of the tasks performed by professionals working in the field of science, research, engineering and technology, together with associate professionals / technicians that provide a support function to those same scientists, technologists and engineers. In these pages, we provide additional illustration in the form of more detailed occupational profiles of specific jobs.

Occupational profile: **Biotechnologist**

Overview	Biological scientists and biochemists examine and investigate the structure, chemistry and physical characteristics of living organisms, including their inter-relationships, environments and diseases. *Biotechnologists* use their scientific knowledge of plants, animals, microbes, biochemistry and genetics to find solutions to problems and develop new products.
Work tasks	Biotechnologists work across three broad disciplines with specific tasks being dependent on the discipline. ■ In environmental biotechnology the focus could be on developing micro-organisms and plants to clean polluted land or water or producing environmentally-friendly raw materials for industry, such as biodegradable plastics from plant starches. ■ In industrial biotechnology it could be on cloning and producing enzymes for use in manufacturing and preserving food and drink (such as beer, cheese and bread) or developing crops that are more resistant to pests. ■ In medical biotechnology the work can involve the study of human genetics, proteins, antibodies, viruses, plants, fungi and bacteria to research and treat diseases/cancers or the development of medicines using techniques such as cell culture and genetic modification.
Sector context	Biotechnologists are required across a variety of sectors including agricultural, the food industry and medicine.
Entry routes	Entrants need a degree in a relevant subject such as biotechnology, bioscience, microbiology, and biochemistry. A postgraduate qualification and several years' experience in the field is required for a research post.
Required skills, interests and qualities	■ Good practical and technical skills ■ Ability in maths, science and IT ■ Good communication skills ■ Understanding of engineering drawings and principles ■ Ability to work methodically and precisely ■ Good problem-solving skills ■ Awareness of health and safety ■ Teamworking skills

Occupational profile: **Mechanical engineering technician**	
Overview	Engineering technicians perform technical support functions to assist engineers with the design, development, operation, installation and maintenance of engineering systems. *Mechanical engineering technicians* design, install and repair plant machinery and parts.
Work tasks	Mechanical engineering technicians work on tasks including: ■ Drawing up plans for new ideas, using computer aided design (CAD) software ■ Investigating and testing ideas to improve existing systems or to overcome machinery or process problems ■ Making parts, and installing and testing instruments or machinery to make sure they run smoothly, safely and meet performance targets ■ Carrying out preventative maintenance and identifying and repairing faults in equipment and machinery.
Sector context	Mechanical engineering technicians work across a variety of industries, undertaking the following tasks: ■ *Manufacturing:* building engine and gear components, maintaining conveyor and packaging equipment, and servicing robotic machinery on production lines ■ *Power, water and processing:* installing and maintaining industrial plant equipment, such as drives, valves and pumps for utility companies ■ *Building services:* servicing lifts and escalators, and installing heating and air conditioning systems ■ *Transport:* repairing mechanical parts on rail engines and signalling equipment.
Entry routes	A typical entry route would be through an apprenticeship, although many recent entrants have gone through higher education.
Required skills, interests and qualities	■ Interest and skills in science, particularly biology and chemistry ■ Good problem-solving skills ■ Ability to work methodically ■ Accuracy and attention to detail ■ Ability to analyse technical and statistical data ■ Good IT skills ■ Good communication skills, both spoken and written ■ Teamworking skills but also the ability to work on one's own initiative.

Scientists use their scientific knowledge to develop products and processes across a wide range of areas. For example, chemists may be involved in the development of new medicines, inventing new artificial fibres and plastics and protecting health by keeping water supplies clean. Biologists may use their knowledge to improve productivity in livestock or crops and to develop new methods to diagnose, monitor and treat illness or disease.

Scientists are often supported by laboratory technicians who help carry out tests, research and investigations. Lab technicians provide all the required technical support to enable the laboratory to function effectively, while adhering to correct procedures and health and safety guidelines. They work across biological, chemical, physical and life science areas, operating in a variety of settings including pharmaceutical and chemical companies, government departments, hospitals and research and forensic science institutions.

Using their knowledge of maths and sciences and their problem solving skills, professional engineers drive the development and implementation of crucial mechanical, chemical, structural and electrical systems. Mechanical engineers may be involved in renewable energy and the installation of off-shore wind turbines, whilst electronics engineers research, design and develop electronic components and equipment in a range of industries including manufacturing (programmable logic controls (PLCs) and industrial machinery) and telecommunications (mobile phones, radio, TV, satellite communications).

Engineering professionals are also involved in the direction of production processes. For example, manufacturing systems engineers design and install new production line systems in factories and manufacturing plants. Professional engineers working across the different engineering disciplines are typically supported by science, engineering and production technicians. Engineering maintenance technicians service and repair electrical and mechanical equipment in a variety of industries, including manufacturing, power generation and rail transport. Quality control technicians check that a company's products meet national and international quality standards by monitoring each stage of production in food and drink manufacturing, manufacturing engineering and other sectors.

Information technology and telecommunications professionals work throughout the UK economy to develop and implement business-critical systems and software, support internal and external clients in the utilisation of technologies and manage major information technology projects. IT specialist managers work in a range of specific roles from data centre managers to IT support managers. Web designers and developers use their creativity and technical skills to design, build and maintain websites.

Occupational profile: **Software developer**

Overview	Programmers and software development professionals design, develop, test, implement and maintain software systems in order to meet specific business needs. *Software developers* design, build and test computer systems that help organisations and equipment to work more effectively.
Work tasks	Developers often specialise in a specific development field - such as mobile phone applications, accounting software, office suites or graphics software - and will have in-depth knowledge of at least one computer language. They will: ■ Discuss requirements with the client and the development team ■ Write test versions of program code ■ Test installation, security and compatibility issues ■ Keep accurate records of the development process, changes and results ■ Review test results and fix technical problems ■ Install a full version of the software and carry out quality checks before going 'live' ■ Maintain and support systems once they are up and running.
Sector context	Software developers work on a wide variety of projects from financial or information databases to manufacturing robotics, and on embedded software found in consumer electronics, like that found in home entertainment systems and mobile applications. IT companies manage their own systems and also run IT systems for other companies on a consultancy basis. In addition, opportunities exist across most sectors, including retail, health, travel and tourism, financial services, government and education.
Entry routes	This is a highly skilled occupation and most people working in it have completed a degree, foundation degree or BTEC HNC/ HND, usually in an IT-related subject or a numerate discipline such as maths or physics.
Required skills, interests and qualities	■ A good knowledge of software and programming languages ■ A creative approach to problem-solving ■ An understanding of development processes like 'Agile' ■ Excellent communication skills and the ability to work with people at all levels, including non-technical staff ■ Good project management skills ■ The ability to work under pressure and meet deadlines ■ Good teamwork skills ■ An understanding of confidentiality and data protection issues.

Profiling STEM occupations

Headlines

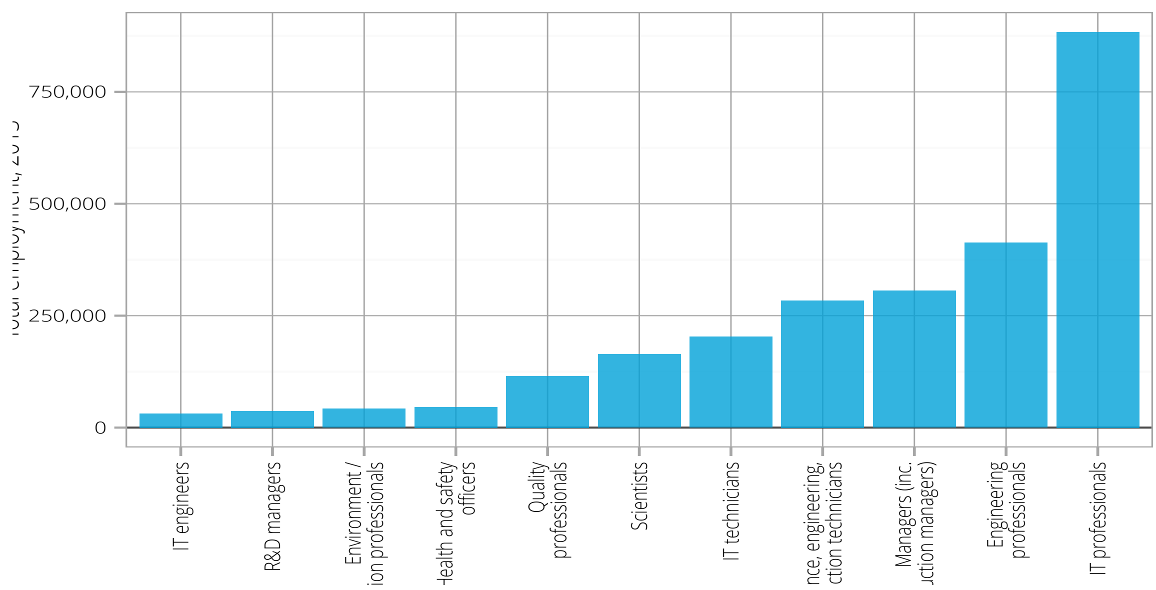
- The high level STEM occupations we have identified contribute 2.8m jobs.
- IT professionals and engineering professionals are largest job families in terms of employment and are expected to have the greatest recruitment needs in future.
- Skill shortages are most significant among engineering professionals, followed by IT professionals and then Science, engineering and production technicians.
- High level STEM employment is widely distributed and is increasingly becoming service-sector based.
- Employment in high level STEM occupations is weighted towards London and the South East but is important in all UK nations and English regions.

Which occupations have a significant requirement for STEM knowledge and skills?

Our approach to defining STEM occupations draws on an objective review of the data together with an element of judgment. Our "long-list" of STEM occupations takes account of the extent to which workers with higher level STEM qualifications are represented in each occupation but also draws on data relating to the utilisation of STEM skills in the workplace (taken from the Skills and Employment Survey). We have then refined the "long-list" based on judgments relating to the policy context and other considerations. The most notable of these refinements are the exclusion of medical and teaching occupations and the addition of some technican occupations, all on the grounds of relevance to the present exercise. The approach is set out in detail in our Evidence Report.

The table on pages 26 and 27 sets out the final list of 38 high level STEM occupations. It is organised by a series of 11 job families that we have adopted to make the analysis of labour market need more manageable. What are the

Figure 5 Level of UK employment within high level STEM job families, 2013



Source: UKCES analysis of Labour Force Survey.

Figure 6 Composition of STEM workers by job family and five indicators

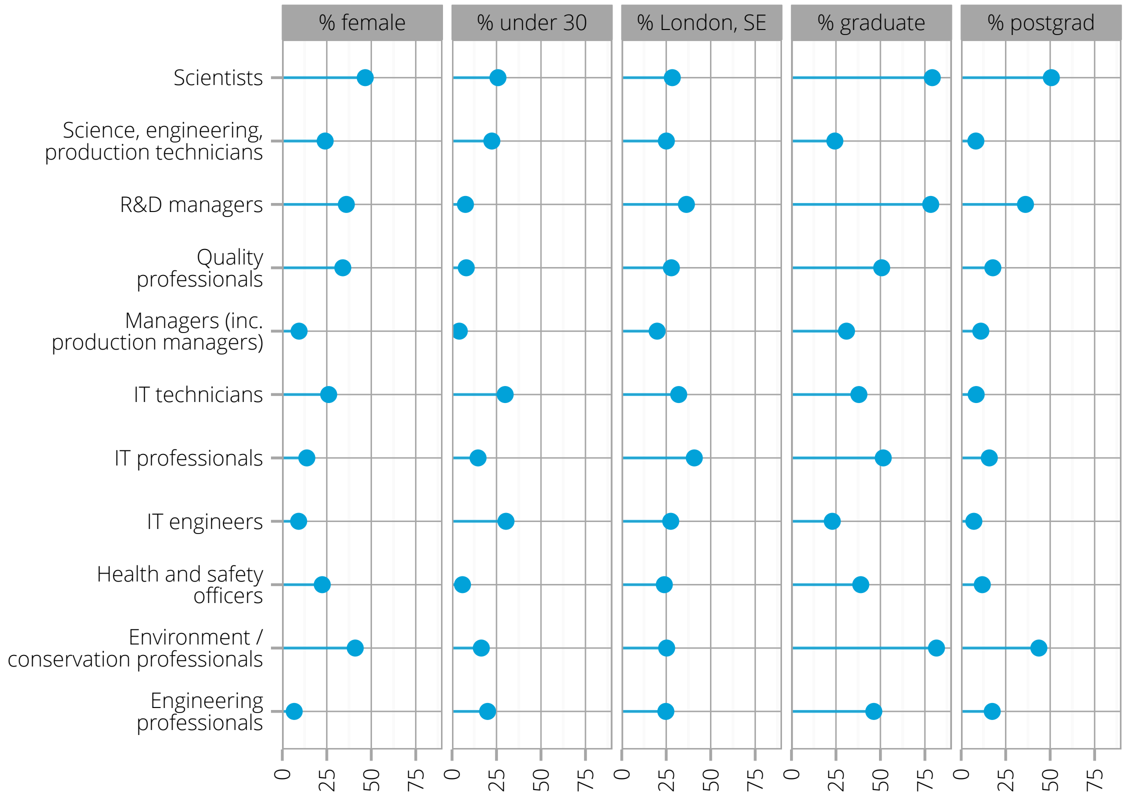
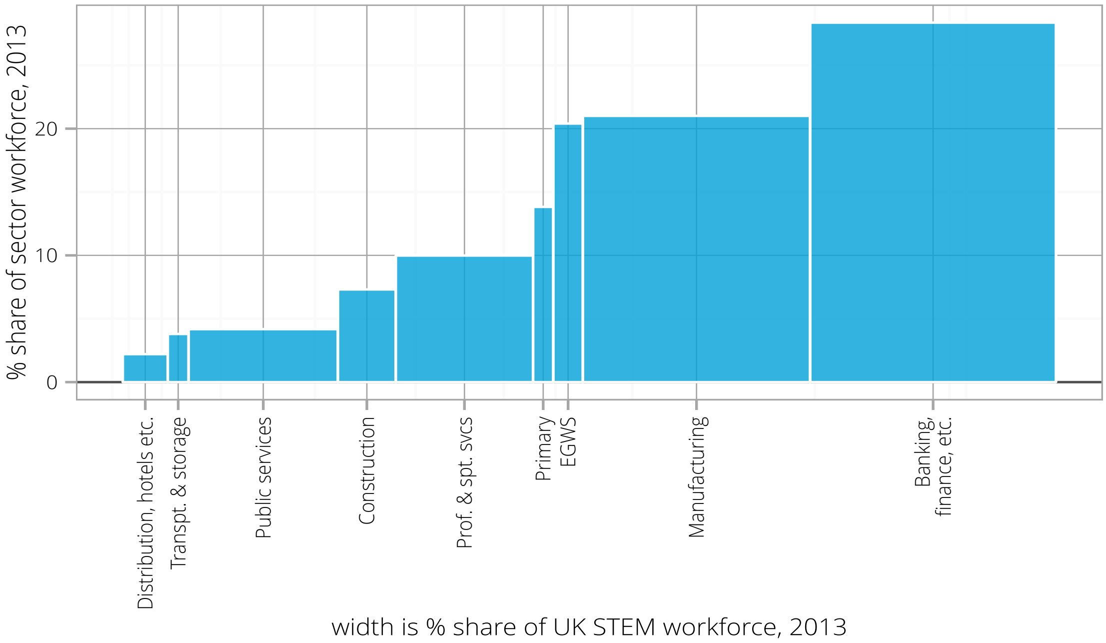
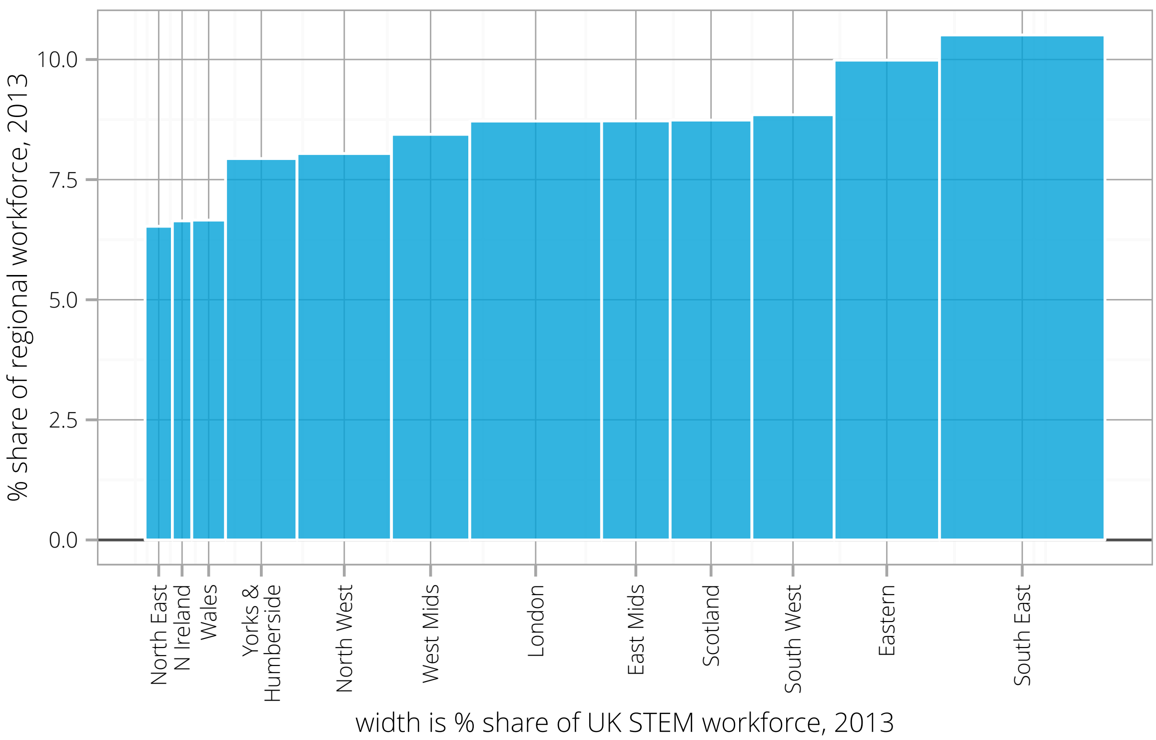


Figure 7 Distribution of STEM workforce by LFS industry sector, 2013



Source: UKCES analysis of Labour Force Survey. In Figure 7, sectors are from INDE07M. Width is share of UK workforce, height is share of sector workforce.

Figure 8 Distribution of STEM workforce by LFS region, 2013



Source: UKCES analysis of Labour Force Survey. Regions are from GOVTOF. Width is share of UK workforce, height is share of regional workforce.

key characteristics of the occupations? In the Evidence Report we profile the 11 job families according to key labour market indicators and also examine their sectoral and spatial profile. This helps to build an understanding of the requirement for STEM skills in the labour market. In this section, we identify the key messages from this analysis.

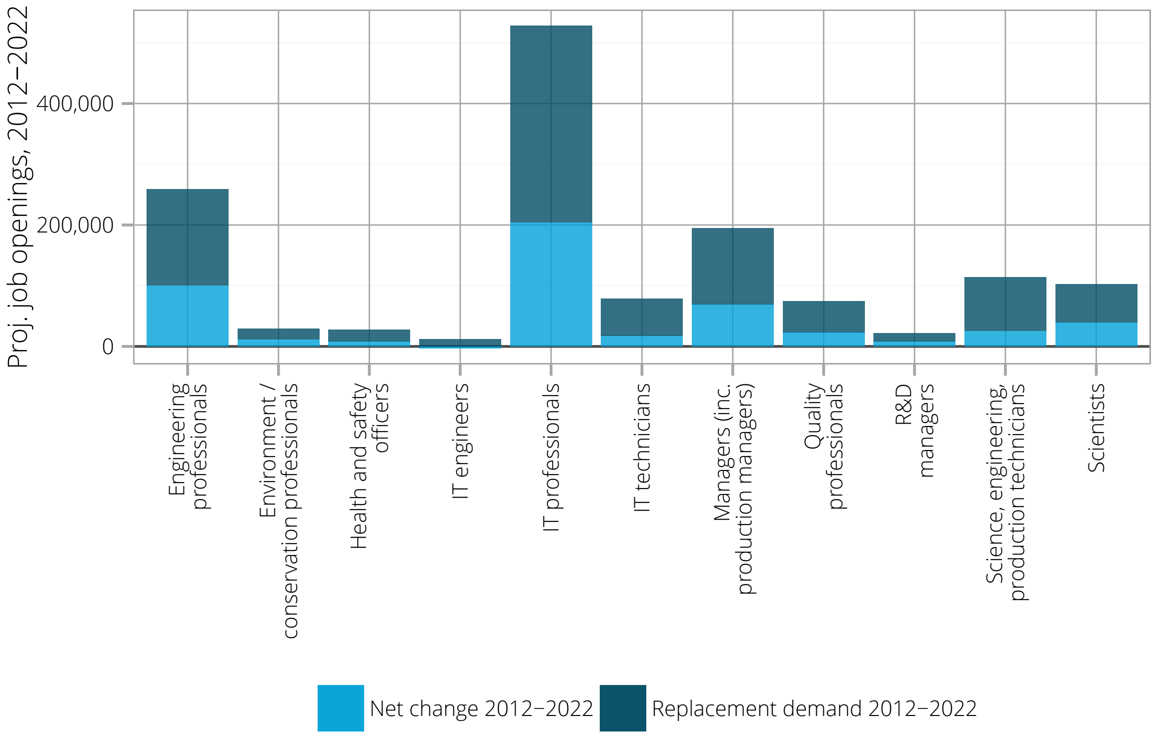
The high level STEM occupations we have identified in our final list[10] contribute total employment of 2.8m
jobs. IT professionals is easily the largest of the job families (accounting for close to 1m jobs) followed by engineering professionals and then managers and science, engineering and production technicians (see figure 5).

A number of the groups are relatively niche in size terms, including environment / conservation professionals, health and safety officers, R&D managers and IT engineers.

Figure 9 shows the number of job openings that we expect to see in each job family, taking into account projections of both net growth and replacement demands. This is the core indicator of the future requirement for recruits into an occupation.

10 Our full "long-list" of high level STEM occupations accounts for more than 5m jobs.

Figure 9 Projected job openings by STEM job family, 2012-2022

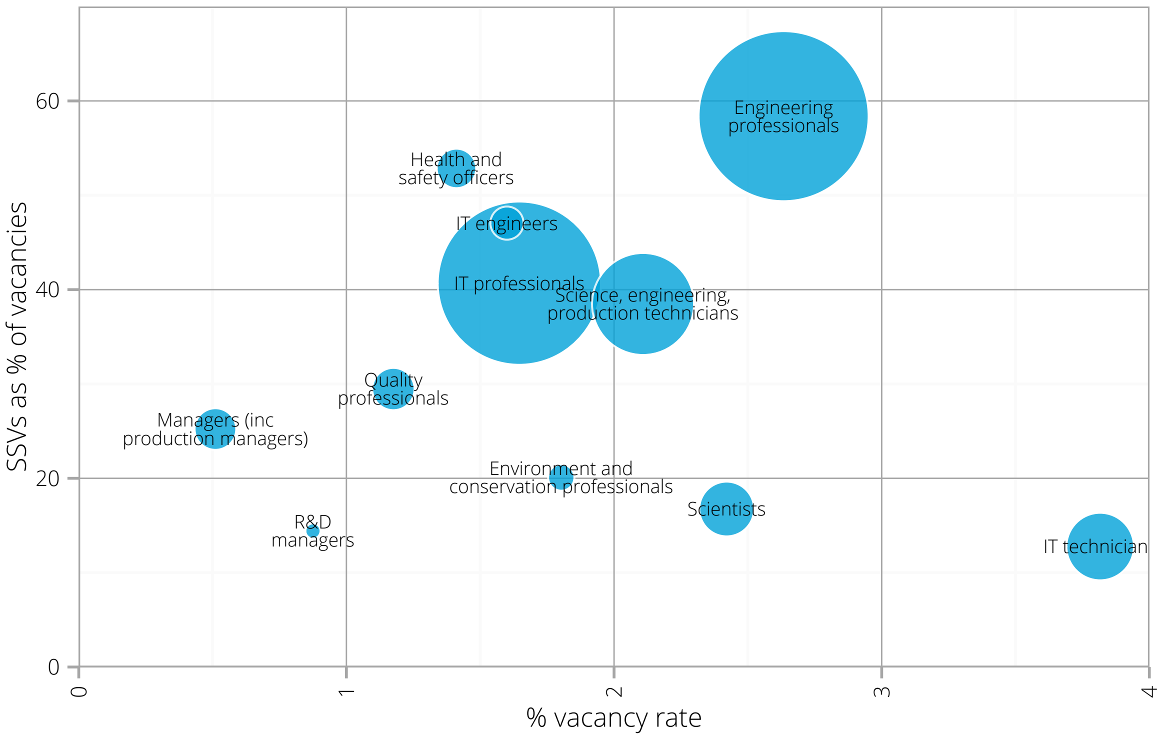


Source: Working Futures 2012-2022. Replacement demand arises from exits from the occupational workforce; net change reflects an expansion in overall employer demand.

IT professionals, engineering professionals and management job families are projected to see the most significant recruitment need in absolute terms, reflecting their large opening stocks of employment and strong projected growth rates of around 20 per cent for each family over the course of the decade. Job openings for science, engineering and production technicians are driven by strong replacement rates.

The profile of workers in each job family varies quite markedly. Women are generally under-represented but particularly among engineering professionals and managers, for example. Certain job families, such as IT professionals, IT technicians and R&D managers are more likely to be employed in London and the South East. Whilst entry routes also vary. For example, scientists are much more likely to be have gone through graduate and postgraduate programmes than engineering professionals.

Figure 10 Vacancies and skills shortage vacancies for STEM job families, 2013



Source: UK Commission's Employer Skills Survey 2013. Bubble size is total number of skill shortage vacancies (SSVs). Vacancy rate is vacancies as % of vacancies plus 2013 LFS employment.

The prevalence of skill shortages within an occupation gives an insight into the extent to which employers can access the skills they need through the operation of the labour market. As we have seen, skill shortages present a particular challenge in the context of STEM occupations. Using analysis of the UK Commission's Employer Skills Survey 2013, we can see that the prevalence of shortages is estimated to be highest for the engineering professional job family (figure 10). Close to 60 per cent of vacancies relating to occupations in this family are difficult to fill due to a lack of candidates with the right skills. The prevalence of skill shortages is also high, at around 40 per cent, for both IT professionals and for science, engineering, production technicians. To place these figures into context the overall density of skill shortages across the UK labour market is around 22 per cent.

With regard to the sectoral profile of employment, manufacturing accounts for the single largest share (see figure 7). However, there is also substantial employment in information and communication (subsumed within Banking, finance etc), professional services and public services.

Employment in STEM occupations is projected to grow to some degree in almost all broad sectors. However, it is the service-based activities, rather than manufacturing, that offer the best prospects for future job growth.

Figure 8 shows how employment in high level STEM occupations is distributed across English regions and the devolved nations of the UK.

It indicates that employment in these roles is unevenly spread, as one would expect in view of the varying size of total employment across nations and regions. Three of the top four nations / regions are in the south eastern corner of England. The two regions of London and the South East together account for more than one third of high level STEM jobs, with combined employment of over 900,000.

This spatial pattern is of interest since there is some evidence that London acts as a magnet to STEM workers at the expense of other parts of the country, reflected in strong commuting patterns into London from neighbouring regions. Data from the UK Commission's Employer Skills Survey indicates that skills shortages relating to high level STEM roles have an above average prevalence in the regions around London but are well below average in London itself.

Assessing labour market need

Our approach to assessing the labour market need of the occupations is founded on an analytical model that takes into account economic signficance of occupations in the form of pay levels; labour demand in the form of both job growth prospects and future recruitment requirements; and business need in the form of skill shortages.

An overall composite score is calculated for each occupation based on the sum of scores for each of the labour market indicators and this is used to rank occupations. Full details of the methodology are provided in our Evidence Report.

The following table shows the 38 occupations, ranked according to their overall score from the modelling exercise.

Our key conclusions concerning labour market need are as follows:

- Our analysis indicates that professional level skills relating to engineering and IT occupations are the leading priority. Occupations in both of these broad groups score consistent highly against all labour market indicators and are therefore positioned in the upper reaches of the ranking.
- The category of manufacturing production managers is also a key occupation in view of its economic significance (reflected in high pay) and the scale of its recruitment needs, although skills shortages are less in evidence.
- The level of labour market need associated with Science, engineering and production, technicians is lower than for engineering and IT professionals. The size of future recruitment needs is limited by moderate prospects for job growth and pay levels are lower, even though the prevalence of skill shortages is comparable to the professional groups.
- For scientist occupations pay levels and the prevalence of shortages are both relatively modest, whilst their comparatively small size in terms of jobs limits the scale of future recruitment needs.
- A key caveat to bear in mind when considering these priorities is the importance of taking a balanced approach to addressing skill needs in view of the strong interdependence that exists in the workplace between the various occupations.
- It is also important to place the results for high level STEM occupations in the context of the wider labour market. Almost all of the featured occupations have strong growth prospects relative to UK employment as a whole, whilst, as we have seen, pay levels tend to compare favourably to non-STEM areas.

Coverage of higher apprenticeships

Higher apprenticeships represent an important option for employers with regard to developing the higher level skills of their people.

As part of our review of the wider evidence we have conducted a high level, indicative analysis of the occupational coverage of existing Higher Apprenticeship frameworks and Trailblazer apprenticeship standards (including standards that are ready for development and those approved for development).

By comparing this analysis with the results of our labour market modelling we can highlight potential gaps in coverage relative to the areas of need we have identified. This may prove useful in guiding the future development of standards.

- There is limited coverage of the various engineering professional roles. Most of the available standards are specific to the automotive and aerospace sectors. Existing frameworks are relevant but the principal focus is on technicians at level 4, rather than at the higher skills level required for professional roles.
- IT professional occupations have good coverage, partly due to the new degree apprenticeship for digital and technology professionals, although there are some apparent gaps. Both IT technician occupations have standards that provide some coverage. IT-related occupations are comprehensively covered at level 4 level by the existing framework for IT professionals.
- There are also apparent gaps in respect of scientific occupations. In particular, there do not appear to be any standards and frameworks that focus specifically on physical scientists.
- Most technician occupations have some coverage in terms of standards and frameworks. Some of these standards are positioned at level 3, however.
- A key general point to note is that many standards only offer narrow coverage of an occupation because they are contextualised to the needs of a vertical industry sector. For example, the only sets of standards specifically focusing on production managers specifically relate to the food and drink industry.

Ranking of high level STEM occupations according to scores against indicators of labour market need

No.	Occupation	Job family	Proj'd change in net employment	Projected job openings	Skills shortages	Median pay	Overall score
1	Programmers and software development professionals (2136)	IT professionals	2.94	2.90	0.42	0.28	1.63
2	Production managers and directors in manufacturing (1121)	Managers (inc. production managers)	3.00	3.00	-0.91	0.51	1.40
3	IT specialist managers (2133)	IT professionals	2.02	1.95	0.42	0.83	1.30
4	Information technology and telecommunications profs n.e.c. (2139)	IT professionals	1.75	1.69	0.42	0.11	0.99
5	Engineering professionals n.e.c. (2129)	Engineering professionals	0.49	0.40	1.60	0.33	0.71
6	Mechanical engineers (2122)	Engineering professionals	0.41	0.32	1.60	0.50	0.71
7	IT business analysts, architects and systems designers (2135)	IT professionals	0.67	0.58	0.42	0.50	0.54
8	Design and development engineers (2126)	Engineering professionals	0.15	0.05	1.60	0.22	0.51
9	Civil engineers (2121)	Engineering professionals	0.23	0.13	1.60	0.01	0.49
10	IT project and programme managers (2134)	IT professionals	0.09	-0.01	0.42	1.34	0.46
11	Electrical engineers (2123)	Engineering professionals	-0.25	-0.35	1.60	0.74	0.43
12	Production and process engineers (2127)	Engineering professionals	-0.17	-0.27	1.60	0.07	0.31
13	Electronics engineers (2124)	Engineering professionals	-0.35	-0.45	1.60	0.20	0.25
14	Information technology and telecommunications directors (1136)	IT professionals	0.02	-0.03	-1.31	2.16	0.21
15	Quality assurance and regulatory professionals (2462)	Quality professionals	0.13	0.28	-0.32	0.09	0.05
16	Web design and development professionals (2137)	IT professionals	0.07	-0.03	0.42	-0.75	-0.07
17	Engineering technicians (3113)	Science, engineering, production, technicians	-0.39	-0.10	0.28	-0.47	-0.17
18	Biological scientists and biochemists (2112)	Scientists	0.30	0.21	-1.19	-0.19	-0.22
19	Health and safety officers (3567)	Health and safety officers	-0.32	-0.27	0.12	-0.44	-0.23

All scores are standardised z-scores, which adjust so that 0 is the mean across jobs, with a standard deviation of 1. z-scores enable comparison of scores across different scales.

No.	Occupation	Job family	Proj'd change in net employment	Projected job openings	Skills shortages	Median pay	Overall score
20	Research and development managers (2150)	R&D managers	-0.32	-0.43	-1.32	0.85	-0.30
21	Quality control and planning engineers (2461)	Quality professionals	-0.51	-0.53	-0.32	-0.22	-0.40
22	Electrical and electronics technicians (3112)	Science, engineering, production, technicians	-0.75	-0.73	0.28	-0.62	-0.46
23	Natural and social science professionals n.e.c. (2119)	Scientists	-0.21	-0.31	-1.19	-0.19	-0.48
24	Waste disposal and environmental services managers (1255)	Managers (inc. production managers)	-0.80	-0.74	-0.66	0.14	-0.52
25	Building and civil engineering technicians (3114)	Science, engineering, production, technicians	-0.81	-0.85	0.28	-0.79	-0.55
26	Planning, process and production technicians (3116)	Science, engineering, production, technicians	-0.75	-0.74	0.28	-0.99	-0.55
27	Laboratory technicians (3111)	Science, engineering, production, technicians	-0.45	-0.20	0.28	-1.88	-0.56
28	Production managers and directors in mining and energy (1123)	Managers (inc. production managers)	-0.63	-0.72	-0.91	0.00	-0.57
29	Environment professionals (2142)	Environment/ conservation professionals	-0.35	-0.45	-0.94	-0.54	-0.57
30	Science, engineering and production technicians n.e.c. (3119)	Science, engineering, production, technicians	-0.70	-0.65	0.28	-1.22	-0.57
31	Environmental health professionals (2463)	Quality professionals	-0.74	-0.81	-0.32	-0.45	-0.58
32	Quality assurance technicians (3115)	Science, engineering, production, technicians	-0.78	-0.78	0.28	-1.11	-0.60
33	Physical scientists (2113)	Scientists	-0.55	-0.66	-1.19	0.00	-0.60
34	IT operations technicians (3131)	IT Technicians	-0.23	0.18	-1.43	-0.97	-0.61
35	Chemical scientists (2111)	Scientists	-0.45	-0.56	-1.19	-0.38	-0.65
36	IT user support technicians (3132)	IT Technicians	-0.40	-0.11	-1.43	-0.98	-0.73
37	Conservation professionals (2141)	Environment / conservation professionals	-0.69	-0.80	-0.94	-0.66	-0.77
38	IT engineers (5245)	IT engineers	-1.11	-0.77	-0.22	-1.13	-0.81

Conclusion

Headlines

- High level STEM skills are of key importance to the performance of the UK economy in terms of jobs, productivity, innovation and competitiveness.
- Engineering professionals and IT professionals appear to be particular priorities in terms of labour market need.
- There appear to be gaps in the coverage of higher apprenticeship standards and frameworks in some in areas of need.
- Apprenticeships need to support coherent career pathways but also provide sufficient coverage of the range of jobs roles within each occupational area.

Our analysis confirms that high level STEM skills are of key importance to the performance of the UK economy in terms of productivity and competitiveness. They also contribute a significant amount of employment: around 2.8m UK jobs based on our fairly tight definition of STEM occupations. High level STEM skills are also demonstrably important to the future development of many of the priority sectors identified in the Government's industrial strategy.

An analysis of trends in the economy and labour market, based on the UK Commission's Future of Work study, indicates that high level STEM skill requirements are being transformed by fundamental global trends relating to business, technology, society and the environment.

On balance it seems that there is no overall undersupply of qualified individuals to meet the demand for high level STEM workers. However, there are acute shortages in specific occupational areas. Investment by employers in the development of their existing staff STEM staff appears to be low relative to comparable occupational areas and may not be sufficient to meet business need.

Focusing down on priorities within high level STEM, engineering professionals and IT professionals represent strong priorities in terms of labour market need, based on our modelling work. Scientist occupations and Science, engineering and production technicians typically rank lower in terms of need, based on our approach.

Production managers in manufacturing could also be seen as a priority occupation, due to the scale of its employment and its economic significance, although evidence of market failure is less strong.

High level STEM jobs are increasingly positioned outside Manufacturing, in the Professional services sector and Information and communication sectors. It seems likely that the changing context in which STEM workers operate impacts on skills requirements. This may have implications for the way in which employers are organised in terms of their standards development role.

High level STEM employment mirrors the wider jobs picture in its concentration in London and the South East, with projections suggesting that this picture is unlikely to change in the medium term.

Our initial analysis of the emerging body of higher level apprenticeship standards, together with existing Higher Apprenticeship frameworks, suggests that at the current time there are gaps in coverage relative to occupations with labour market need. Some occupations appear to have no coverage (e.g. some scientific occupations) whilst others have coverage but the available standards appear to be relatively niche rather than covering the full scope of the occupation. Consideration will need to be given to these areas as the standards development programme progresses.

The primary focus of existing higher apprenticeship frameworks is on skills and knowledge at level 4. Our assessment of need suggests that there will need to be a continued shift in focus towards higher levels, within standards development, in order to provide effective progression routes to the professional occupations that we have identified as labour market priorities..

Recommendations

Based on these conclusions we make the following recommendations:

- Our analysis reinforces the importance of developing coherent career pathways within STEM occupations. In order to address priority needs, employers should actively consider the extent to which higher apprenticeships, including degree apprenticeships, can provide a relevant development route into professional level roles requiring STEM knowledge and skills at degree level. Employers should also consider the suitability of this route for progression into production manager roles.
- Working with employers, Government should consider how better general coverage of high level STEM occupations can be achieved through the standards development process. A rational approach is required that ensures that the broader requirements of an occupation are covered at the same time as more niche and sector-specific needs. Some standards, although notionally focused on niche areas, may have wider applicability across the occupation with limited modifications.
- The issue of diversity within high level STEM roles is not part of the scope of this review. However, its limited consideration of the evidence around gender balance supports the view that employers need to make major efforts to widen the talent pool available to them by making these occupations more attractive to women.

We believe that this review provides a platform for further, more specific research. Industrial Partnerships and other employer-led bodies are well placed to address this need. We recommend that the following areas should be considered.

- An ongoing programme of research to assess the changing skills needs associated with occupations, including the needs of particular niche areas within occupations that may have particular importance for business performance.
- An investigation of the extent to which the changing sectoral context within which STEM skills are applied is influencing the nature of skill requirements. For example, do engineers working within a consultancy setting require different skills to those working directly for a manufacturing organisation?
- An analysis of progression pathways within the STEM occupational sphere. This intelligence could be used to ensure that career pathways are effectively supported by apprenticeships.
- Further analysis of the level of skill requirements associated with science, technology and production technicians to ascertain the extent to which skills at level 4 and above are required within these occupations.
- An investigation of skills investment patterns in respect of high level STEM occupations and whether the level of investment is sufficient to meet business needs.
- A more detailed assessment of the spatial pattern of STEM skill shortages including an investigation of the extent to which London is attracting skilled individuals at the expense of neighbouring regions.

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