UK COMMISSION FOR EMPLOYMENT AND SKILLS

Reviewing the requirement for high level STEM skills

Evidence Report 94
July 2015

[This page is intentionally left blank]

Reviewing the requirement for high level STEM skills

July 2015

[This page is intentionally left blank]

Foreword

The UK Commission for Employment and Skills (UKCES) is a publicly-funded, industry-led organisation providing leadership on skills and employment issues across the UK. Our ambition is for a sustained recovery driven by the skills and talents of people, with the creation of “ladders of opportunity” for everyone to get in and on in work.

As a central part of our approach we mobilise impartial and robust business and labour market research to inform choice, practice and policy. Our key audiences include business, trade unions, government, industry bodies and education providers.

This review of STEM (Science, Technology, Engineering and Mathematics) skills seeks to deploy the UK Commission’s intelligence about the labour market for the specific purpose of assessing priorities for investment with regard to the development of work-based skills solutions. STEM skills are widely accepted to be of critical importance to the future international competitiveness of the UK and play a key role in driving productivity, growth and higher living standards. It is vital that decisions concerning such economically valuable skills are guided by a sound evidence base.

This report is primarily intended to inform the thinking of employers as they consider the strategic skills solutions needed by their respective sectors. It is also a resource for policy makers as they seek to support and enable employer-led strategies, particularly in areas of market failure. There is a strong consensus among both employers and policy-makers that work-based pathways, including higher apprenticeships, should play a central role in the development of higher level skills, particularly in the STEM sphere.

This Evidence Report examines the broader labour market context for high level STEM skills based on a detailed evidence review. We then identify high level STEM occupations based on the extent to which workers with higher level STEM qualifications are represented in each occupation but also taking account of the use of STEM skills in the workplace. We assess these occupations using an analytical model that draws on a number of indicators of labour market need. Our assessment of labour market priorities is compared with an indicative analysis of the occupational coverage of higher apprenticeship frameworks and standards as a basis for highlighting potential gaps and areas for future development.

Our analysis draws heavily on the UK Commission's wider work on the labour market and its core intelligence products, which provide rich and distinct business intelligence. It is this wider labour market analysis that has informed our understanding of developments in the economy, occupational employment trends and business needs.

Sharing the findings of our research and engaging with our audience is important to develop the evidence on which we base our work. Evidence Reports are our chief means of reporting our detailed analytical work. All of our outputs can be accessed online at https://www.gov.uk/government/organisations/uk-commission-for-employment-and-skills

But these outputs are only the beginning of the process and we engage in other mechanisms to share our findings, debate the issues they raise and extend their reach and impact.

We hope you find this report useful and informative. If you would like to provide any feedback or comments, or have any queries please e-mail info@ukces.org.uk, quoting the report title or series number.

Lesley Giles

Deputy Director

UK Commission for Employment and Skills

Table of Contents

Tables and figures

Executive Summary

Introduction

In order 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. 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. 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 bodies.

Why action on high level 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. Although these skills are of key importance there is evidence of significant deficits.

STEM graduates are strongly correlated with innovation and not just for traditional STEM enterprises. According to Levy and Hopkins (2010) 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.

In its international benchmarking study, BIS (2014) found 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, the report highlights a problem of insufficient domestic human capital to exploit science and innovation, including deficits of domestic STEM talent and of Masters/PhD graduates working in research.

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, 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 occupational sub-major groups. The results from previous iterations of the survey suggest that this is a persistent problem that pre-dates 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, 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.

On balance, the wider evidence 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 insufficient potential recruits with specific skills. Qualitative evidence suggests that reasons for this include a lack of degree courses with the right technical content, a lack of well-rounded candidates with practical work experience and broader competencies, such as mathematical capability.

There is some evidence to suggest that investment by employers in the development of their existing staff STEM may be low relative to comparable occupational areas and may not be sufficient to meet business need. This needs to be explored further.

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.

A key illustration of the important 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. Based on a detailed examination of the strategy documents we set out 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.

Identifying high level STEM occupations

Which occupations have a significant requirement for STEM knowledge and skills? As a starting point we need to identify these occupations to provide a basis for our analysis of labour market need.

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, based on an analysis of the Labour Force Survey but also draws on data relating to the utilisation of STEM skills in the workplace, taken from the Skills and Employment Survey (Felstead *et al*., 2014). We have then refined the "long-list" based on judgments relating to the policy context and other considerations.

The final list comprises 38 high level STEM occupations (see Table 11). It is organised by a series of 11 job families that we have adopted to make the analysis of labour market need more manageable.

Profiling high level STEM occupations

What are the key characteristics of the occupations? 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.

The high level STEM occupations we have identified 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. 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.

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, with future job growth expected to be focused on areas like Professional services and Information and communication.

Moreover, a disproportionate share of high level STEM vacancies (relative to employment) are found in the Professional services sector, suggesting that the sector plays an important role in job creation.

This raises the question of how standards and frameworks should be contextualised to fit with these settings and how employer networks might best be organised to develop them.

Employment in high level STEM occupations is weighted towards London and the South East but is important in all UK nations and English regions. Specific regional and local employment specialisms need to be assessed in order to define priorities at these levels.

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 significance 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.

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.

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 an 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 some coverage of management roles, with standards under development for production managers in the food sector under development whilst the existing framework in sustainable resource operations relates directly to waste disposal and environmental services managers.
- There is limited coverage of scientist occupations, with one set of standards under development in relation to biological scientists. However, existing frameworks provide coverage for biological and chemical scientists. There does not appear to be any direct coverage of physical scientists in either standards or frameworks.

- 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.
- A number of IT professional unit groups are not currently specifically covered by standards but we can assume that these gaps will be addressed by development work in support of the forthcoming degree apprenticeship. Both IT technician occupations have standards that provide some coverage. IT-related occupations are also comprehensively covered at level 4 level by the existing framework for IT professionals.
- Most science, engineering and production technician occupations have some coverage in terms of standards that are available or under development, although some of these standards are positioned at level 3.
- Elsewhere, there are a number of occupations for which there do not appear to be any directly applicable standards, including the quality control and assurance occupations, research and development managers, conservation professionals and health and safety officers.

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.

Conclusions

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.

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.

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.

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 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.

More generally, the primary focus of 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 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.

Further research

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 analysis of progression pathways within the STEM occupational sphere. This intelligence could be used to ensure that career pathways are effectively supported by apprenticeships.
- 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?
- 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.

1 Introduction

Chapter Summary

- In order to develop the advanced skills needed by an advanced economy, the Government is committed to widening access to higher level skills through higher apprenticeships.
- As part of this effort the Government is working with STEM employers to develop higher apprenticeships (including degree apprenticeships) in occupational areas that have the greatest need and which face a risk of needs not being met.
- Government has asked the UK Commission to undertake a review of high level STEM skills and advise on the STEM occupations where there are the most pressing labour market needs.
- This brief has a good fit with the UK Commission's own agenda. In its recent Growth Through People statement, the UK Commission called for a greater range of options to combine work and study to meet the UK's technical skills needs.

1.1 The role and remit of the UK Commission

The UK Commission for Employment and Skills (UKCES) is a publicly funded, industry-led organisation providing leadership on skills and employment issues across the UK.

Together, our Commissioners comprise a social partnership of senior leaders of large and small employers drawn from industry, trade unions, third sector, further and higher education and across all four UK nations.

Our Vision, as set out in our business plan for 2014/15, is to create with industry the best opportunities for the talents and skills of people to drive competitiveness, enterprise and growth in a global economy. We are working with industry and Government to secure improvements in the skills and employment system.

Over the next three years our Ambition is to see industry in the UK create "ladders of opportunity" for everyone to get in and on in work. This means employers improving entry routes into the labour market for young people, ensuring the existing workforce has the skills businesses need to compete and individuals need to progress, and deploying those skills in a way that drives productivity and growth.

Providing access to intelligence about the labour market and careers opportunities is a critical part of achieving this Ambition. Not only is it crucial, to enabling young people to get into work and effectively navigate a jobs market that is more complex than ever before, it is also vital for more established workers who are seeking to progress and who need reliable information about future career opportunities and the right pathways to pursue to reach higher rungs of the career ladder.

Research and intelligence is integral to the UK Commission's way of working, as reflected in the four core elements of our approach, set out in our latest business plan.

We are commissioner-led, with 30 leaders, drawn from a variety of sectors. This means the Commission forms a strong social partnership, providing a unique perspective that is based on the diversity and independence of Commissioner thinking. Consequently, we are able to reach out into industry and take a long term, 'big picture' view of skills and jobs for the UK. Our Commissioner leadership also provides access to distinctive insights into the way in which the wider labour market is evolving, and the actions of specific industries and occupations are being shaped by key drivers including technology and globalisation.

Our approach is also explicitly evidence-based. We apply impartial and robust business and labour market research, in combination with commissioner insights, to inform choice, policy and practice in the field of employment and skills.

This relies upon an open and collaborative approach. We work with government to bring forward effective policy solutions and with business to influence business behaviour. In both cases this work is founded on robust intelligence. Moreover, we pursue transparency by working to improve access to our data and intelligence, through our LMI for All open data initiative, for example.

The UK Commission is focused on undertaking research and securing improvements in areas where we can make the biggest impact. This is partly about influencing government policy and the design of the employment and skills system. But, it is also about enabling employers to take a strong leadership role. As our broader research has shown (see for example our Employer Ownership vision and the recent skills statement Growth through People) employer leadership on skills, in partnership with Government and wider players is essential to a strong system, and improving the employment and learning opportunities on offer. High quality information about the labour market, clearly then plays an important role in shaping investment behaviour and the actions businesses and individuals take.

1.2 Background to the review

It is widely recognised that the future prosperity of the UK depends on its ability to reshape its economy around high value, knowledge-intensive activities within an increasingly competitive global economy. To address this challenge 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. Higher apprenticeships seek to widen access to higher level skills and also to support progression for those already qualified at level 3 through an advanced apprenticeship. In addition 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.

Higher apprenticeships are available at a range of levels, from the equivalent of a foundation degree to a bachelor's degree and soon at master's degree level in some sectors.

In line with its commitment, Government has asked the Skills Funding Agency to support 20,000 higher apprenticeships by July 2015 and has announced an additional £40m to fund places up until July 2015, and an extra £20m to fund the higher educational element to the end of March 2016.

As an extension to higher apprenticeships the Government has recently announced that it will in future support industry-backed degree apprenticeships in the digital sector, allowing young people to complete a full honours degree alongside their employment.

1.2.1 The requirement

In developing the higher apprenticeship programme there is clear value in prioritising those areas of the labour market in which the need is greatest. As well as being crucial to innovation and growth there is strong evidence that some high level STEM occupations face acute and persistent skill shortages, with employers pointing to a lack of UK candidates of suitable quality in terms of STEM skills but also in terms of broader competencies. Hence, the Government is working with employers in sectors which have a strong need for STEM skills to develop higher apprenticeships in key occupational areas.

In support of this process 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 higher apprenticeships in the STEM sphere. An agreed feature of this review is that it should be founded on a robust analysis of high quality labour market data.

1.3 Aims, objectives and scope of the review

We have distilled the above requirement into a stated aim and set of objectives, as provided below. In broad terms the review seeks to assess labour market priorities in the field of higher level STEM skills, primarily on the basis of an analysis of labour market data. We accept, however, that this type of data-driven analysis can only take the process so far. Ultimately, employers are the authoritative source of understanding on how skills are used in the workplace and what skills are needed. Therefore, our objectives also reflect a need to share the results of our review with employers, government and other stakeholders to inform a debate that we hope will enhance and refine the conclusions presented in this document.

Aim

To assess high level STEM occupations according to labour market need, in order to inform the development of high level skills solutions including higher apprenticeship standards.

Objectives

1. To review the existing evidence on higher STEM skills requirements, including existing development pathways.
2. To identify a list of high level STEM occupations to be considered within the review process.
3. To develop an analytical model that can be used to assess which STEM occupations have the most pressing labour market needs using common and consistent labour market data.
4. To conduct an initial examination of the occupational coverage of available apprenticeship standards and frameworks relative to the STEM occupations with the greatest labour market need.
5. To use the results of the analysis as a basis for discussion with employers, Government and other stakeholders to achieve a broad consensus on priorities.
6. To communicate the results of the analysis to key stakeholders including employers and Government.

Scope

The review is primarily intended to inform the development of higher apprenticeships in the STEM field in England. Since higher apprenticeships cater for skills development at NQF levels 4 to 7 our interest is in occupations that require STEM skills at this level.

Skills are a devolved matter in the UK. Although in the report we present elements of analysis that cover the devolved nations of the UK as well England and its nine regions, we do so primarily to provide a complete picture and for purposes of comparison. The conclusions and recommendations are aimed primarily at employers and policy makers in England although we hope that stakeholders in the nations will find the supporting analysis useful.

The primary focus of the review is on understanding labour market need with reference to high level STEM occupations. Although some consideration is given to the question of the availability of frameworks and standards to address occupations with the greatest labour market need, this is for illustrative purposes and the review does not seek to evaluate the current development programme for standards and frameworks.

A key element of the review is a model of labour market need which is designed to aid understanding of labour market priorities. This has been developed for the specific purpose of this review and it should not be assumed that this can be used as a general tool for determining curriculum priorities in the wider education and training system.

1.4 Overview of our approach

In addressing these objectives our approach takes in the following elements.

Evidence and literature review. The critical issue of STEM skills has high visibility in the field of public policy and is the subject of a lively ongoing debate. This means that there is a substantial body of evidence and literature residing not just in the UK but also internationally. We have therefore conducted an evidence review to ensure that our analytical approach takes account of existing thinking on STEM skills and that the analysis is suitably grounded in an understanding of the wider labour market evidence and policy context.

Defining STEM skills. In order to assess priorities in respect of STEM skills it has been necessary to define what we mean by STEM skills and then to operationalise that definition in such a way to enable us to analyse labour market need using the available data. Our analytical approach centres on occupations. Occupation is the pre-eminent indicator of a job's skill level and skill content and therefore we have used it as the organising framework for assessment of labour market need.

Developing and applying an analytical model for assessing the labour market need associated with high level STEM occupations. Our model uses data from robust sources to assess occupations on an objective basis, taking into account indicators of economic significance, business need and market failure.

Reporting. The main output of this review is this document, part of the UK Commission's Evidence Report series. In addition we have produced a short summary, also available on the Gov.uk website.

1.5 Structure of the document

In setting out our review, this document is structured as follows:

Chapter 2 sets the context by providing an overview of the labour market for STEM skills. This chapter reviews evidence relating to the importance of STEM skills to the UK economy and considers how the requirement for STEM skills is changing in response to global trends, including changing technology and globalisation. It also examines market failures relating to STEM skills, most notably skill shortages, and what the underlying causes for these might be.

In chapter 3 we work through the process of identifying the high level STEM occupations that form the basis and scope for our subsequent assessment of labour market need.

We then provide a profile of these occupations in chapter 4, including their size in employment terms, their susceptibility to skill shortages and their future job prospects. We also consider how employment in these occupations is distributed spatially and sectorally. This analysis provides context to the results of the modelling presented in the next section but also raises important points about how high level STEM skill needs should be addressed in practical terms.

Chapter 5 presents the results of our labour market modelling and highlights conclusions about key priorities within the sphere of high level STEM skills.

In chapter 6 we examine the extent to which high level STEM occupations, including those with the greatest labour market need, are covered by available apprenticeship frameworks and standards.

Chapter 7 draws together our conclusions and recommendations.

Throughout the document we present conclusions but also important discussion points, which are intended to provide a basis for wider debate.

2 The labour market for high level STEM skills

Chapter Summary

- In this chapter we set out our review of the existing literature and evidence relating to STEM skills in order to provide context to the review and also to demonstrate how our approach and findings have been shaped by existing knowledge.
- High level STEM skills are critical to the process of innovation and will therefore be increasingly important to future competitiveness in global markets.
- The wage premia associated with STEM occupations and with many STEM qualifications suggests that STEM skills have a positive impact on productivity as well as upon individual rewards.
- As with skills in general, STEM skill requirements are evolving in response to deep-seated global trends. For example, there is a growing requirement for a multi-disciplinary approach in the workplace, remote working is becoming more common place etc. Particular trends like the rise of Big Data and the digitalisation of production are having a fundamental impact on STEM disciplines.
- With regard to supply, the number of higher education qualification achievements in STEM subjects has increased significantly in recent years, 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.
- Entry routes into high level STEM jobs vary, with some occupations dominated by graduate entry and others traditionally entered via progression routes grounded in the workplace. Non-graduate qualifications at level four and above do not have a strong presence.
- There is some evidence to suggest that the incidence of workplace training for high level STEM workers is relatively low.
- Projections of labour supply and demand do not suggest that there is an overall shortage of STEM graduates.
- However, there is evidence of persistent shortages of some STEM skills. In some circumstances employers cannot get the specific skills they need.
- The skills system does not always generate the skills that are needed for the workplace.
- A work based approach to the development of high level STEM skills is important in terms of providing relevant skills and retaining talent.

2.1 Introduction

There is a considerable base of evidence and knowledge relating to the issue of STEM skills. It is essential that we take proper account of the lessons from existing research. In this chapter we examine the evidence base with the following key questions in mind:

- How important are STEM skills to the UK economy?
- How is the UK performing in terms of its supply of STEM skills?
- What is the evidence of deficiencies of STEM skills and what are the probable causes of these deficiencies?

We consider the detailed question of defining STEM skills in chapter 3.

We have used the answers to these questions to inform our approach to this review and to shape our conclusions and recommendations, in conjunction with the results from our own labour market analysis and modelling.

2.2 The value of STEM skills

It is widely argued that the UK's economic future depends on its ability to compete on a global basis in high value, innovative and knowledge-intensive activities and that this in turn relies upon the availability of a highly skilled science, technology, engineering and mathematics workforce.

STEM graduates in particular are correlated with innovation and not just for traditional STEM enterprises. According to Levy and Hopkins (2010) 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.

With its relatively high labour costs the UK cannot hope to compete in international markets on the basis of standard products, services and processes. Its businesses must add value through continuous innovation and invention (Porter and Stern, 2002). In this regard STEM skills play a central role in the "megatrends" that are transforming the global economy and shaping the future of work (see section 2.4 below).

Similarly, the determination to rebalance the UK economy depends on sectors that are reliant on STEM skills, including export-oriented and investment led sectors such as advanced manufacturing, the digital economy and green energy (Royal Academy, 2012). The availability of sufficient STEM skills is also critical to the security of vital supplies and services: sectors including communication and IT, water, energy, food all rely on these skills to varying extents.

A major cause for concern is the UK's current poor performance on productivity. STEM-intensive sectors have an important role to play in addressing this issue since they make a disproportionate contribution to GVA. In this context we need to bolster productivity in key sectors in which the UK under-performs by international standards, such as mechanical engineering, electrical machinery and component manufacturing.

The UK is by no means acting in isolation in its efforts to upgrade its STEM skills. Competitor nations including a range of emerging economies are targeting support on STEM-based sectors. The Global Innovation Index 2014 ranks the UK second of 143 countries in terms of its overall innovation performance. However, it ranks lower, 10th, on human capital and research and only 37th with regard to the proportion of graduates in science and engineering.

In its international benchmarking study, BIS (2014) found that the UK's science and innovation system is hampered by weaknesses in its talent base. As well as low basic skills (numeracy, literacy, ICT) and below-average management skills, the report highlights a problem of insufficient domestic human capital to exploit science and innovation, including deficits of domestic STEM talent and of Masters/PhD graduates working in research.

The role of STEM skills in driving productivity and higher living standards can also be examined from the point of view of the wage premia associated with STEM qualifications and occupations.

There is good evidence that wage premia exist for many, but by no means all, STEM qualifications. Scientific qualifications are less likely to offer a premium than qualifications in technology, engineering and mathematics (Greenwood *et al*, 2011).

Those working in STE (science, technology, engineering) occupations earn a great deal more than those who are not in STE occupations (an estimated 19 per cent) although this is less so for science and more so for technology and engineering.· Moreover, the premium from working in a STE occupation is largely for those working at intermediate and lower level occupations (i.e. not at professional or managerial level).

In many instances, STEM qualifications attract a further additional premium if they are used in a STE occupation. Therefore, individuals earn a premium from having a STEM qualification and then a further premium from working in a STE occupation.

However, demand for STEM skills is widespread, extending to occupations and sectors not traditionally viewed as being STEM-based. According to Bosworth (2013) Core STEM occupations employ only 40 per cent of Core STEM degree holders; whilst Core STEM sectors only employ 45 per cent of Core STEM degree holders. This dispersion reflects the value placed on the foundation competencies that underlie STEM skills and their general marketability (Royal Academy, 2012). An example of this would be the way in which STEM skills (specifically mathematics) are required to support innovations in financial modelling in the finance sector.

2.3 STEM in the workplace: sectors and occupations

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?

2.3.1 Industry sectors

In his review of the supply and demand of STEM skills, Bosworth seeks to use empirical methods to identify detailed industry sectors with a strong requirement for high level STEM skills. The approach is based on a combination of two measures: density of such skills within each sector (proportion of total employment in the sector that is made up of STEM graduates) and each sector’s share of total STEM skills (proportion of all STEM graduates working in the sector).

Based on this analysis the detailed industries with the highest proportion of “core” high level STEM skills within their workforces first of all relate to scientific research and development, including Research and experimental development on biotechnology (SIC 72.11) and Other research and experimental development on natural sciences and engineering (72.19).

Technical consultancy activities also have among the highest representation of STEM skills. Engineering activities and related technical consultancy (SIC 71.12) ranks particularly highly. This category includes design activities for industrial process and production. Other professional, scientific and technical activities n.e.c. is also high in the ranking. This category includes environmental consulting activities.

Activities falling within the broad scope of information and communication also feature high in the ranking, including Other software publishing (58.29), Computer consultancy activities (62.02) and Computer programming activities (62.01).

Finally, a number of niche, science-intensive manufacturing activities demonstrate a strong requirement for high level STEM skills, including the manufacture of other inorganic basic chemicals (20.13), manufacture of soap and detergents (20.41) and manufacture of irradiation, electromedical and electrotherapeutic equipment (26.6).

In conclusion then, the strongest requirement for high level STEM skills is in industries pursuing the following activities: 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.

We examine the sectoral distribution of employment in high level STEM occupations using our own definition in section 4.4.

2.3.2 Industrial strategy sectors

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. A 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 following 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 (a broad sector which covers medical devices, medical diagnostics and pharmaceuticals, through to synthetic and industrial biotechnology) is defined by the application of biology. 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 (BIS, 2011a). Agri-tech is another sector science-based sector, profiled in more detail below.

Case study: Agri-tech

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 agricultural 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 identified 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

Advanced manufacturing activities base their competitive advantage on constant innovation, developing new processes, products and solutions to solve problems and better meet customer needs. For example, 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 (BIS, 2013a). Aerospace is another example of a key sector in advanced manufacturing and is profiled in more detail below.

Case study: Aerospace

The UK is Europe's number one aerospace manufacturer, second only to the United States globally. UK firms produce the most advanced and valuable elements of today's airliners including the wings, engines, aerostructures and advanced aircraft systems. The sector supports more than 3,000 companies distributed across the UK, employing around 230,000 people within the supply chain. It creates annual revenues of over £24 billion and exports circa 75 per cent of what it produces, making a positive contribution to the UK's trade balance.

The UK aerospace industry has excellent opportunities for growth, 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 is a highly R&D intensive industry with annual R&D spend of some £1.4 billion representing circa 12 per cent of total R&D spending in UK manufacturing. As a result of pressure from airlines to reduce operating costs, combined with the need to reduce the environmental impact of aircraft the next generation of aircraft will feature substantially different product and manufacturing technologies from those used today. This makes investment in R&D particularly critical.

For example, new materials such as composites are increasingly being used in aerospace but are being applied in the context of traditional aircraft designs. The challenge will be to take full advantage of the properties that these materials offer by applying radical new design options and by optimising manufacturing processes to allow structures using these materials to be made cheaply at high production rates.

In order to compete with low-cost global manufacturing centres UK aerospace suppliers need to differentiate themselves in a number of ways. They can be more innovative in the application of materials, technology, production equipment and processes into their manufacturing systems. They can also optimise transport and logistics networks to secure efficiencies in the flow of materials and components. These kinds of innovation require world-class production knowledge.

In order to address its strategic challenges it is vitally important for aerospace to secure 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 has identified skill shortages in a number of areas including fatigue and damage tolerance, composites, stress and licensed engineers. Some of the most severe shortages are faced by firms seeking to recruit technicians skilled in working with composite materials, which require different skill sets to those trained and experienced in metallics.
>
> *Source: BIS, 2013b*

Companies specialising in the development and implementation of information and communications technology comprise an important vertical sector within the UK economy. However, digital activities also pervade the wider economy and are becoming increasingly important to the future of all types of business.

> **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 the transformative effect of digitisation include virtual prototyping which has transformed manufacturing and design, or the insights into customer shopping habits gained by retailers from big data analytics.
>
> 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 (Tech Partnership, 2014). 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, 2013c

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.

2.3.3 Occupations

High level STEM occupations make a practical contribution in a wide variety of ways to the operation and performance of UK businesses and the wider economy. Below we provide an 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. We provide additional illustration in the form of more detailed occupational profiles of specific jobs.

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.

Occupational profile: Biotechnologist

Biological scientists and biochemists examine and investigate the structure, chemistry and physical characteristics of living organisms, including their inter-relationships, environments and diseases.

The following specific example relates to biotechnologists.

Overview of role

Biotechnologists use their scientific knowledge of plants, animals, microbes, biochemistry and genetics to find solutions to problems and develop new products.

Examples of 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.

Sectoral 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

- 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
- Understanding of engineering drawings and principles
- Teamworking skills but also the ability to work on one’s own initiative.

Source: National Careers Service

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 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 and satellite communications). Engineering professionals are also involved in the direction of production processes. 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 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.

Occupational profile: Mechanical engineering technician

Engineering technicians perform technical support functions to assist engineers with the design, development, operation, installation and maintenance of engineering systems.

The following specific example relates to a mechanical engineering technician.

Overview of role
Mechanical engineering technicians design, install and repair plant machinery and parts.

Examples of work tasks

- 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.

Sectoral 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
- 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.

Source: National Careers Service

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

Programmers and software development professionals design, develop, test, implement and maintain software systems in order to meet specific business needs.

The following specific example relates to software developers.

Overview of role
Software developers design, build and test computer systems that help organisations and equipment to work more effectively.

Examples of work tasks
The typical tasks involved in a software development assignment might include:

- 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.

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.

Sectoral 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 have large IT departments to 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

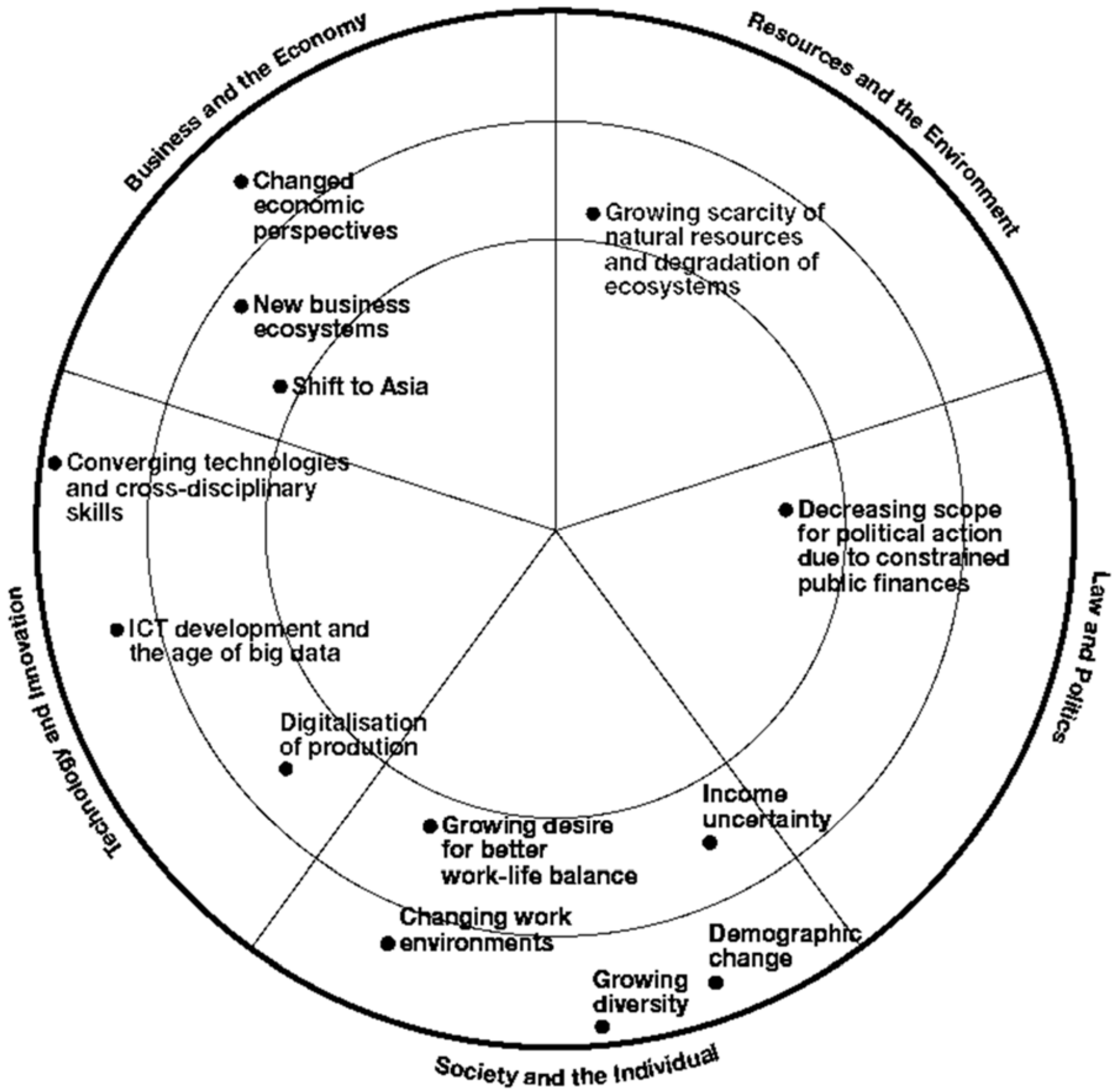
- A good knowledge of software and programming languages
- A creative approach to problem-solving
- an understanding of development processes like 'Agile'
- Excellent communication skills and the ability to work with people at all levels, including non-technical staff
- Good project management skills
- The ability to work under pressure and meet deadlines
- Good teamwork skills
- An understanding of confidentiality and data protection issues.

Source: National Careers Service

2.4 Drivers of demand for STEM skills

The UK Commission's recent Future of Work study (Störmer *et al*, 2014) analyses the trends which are shaping UK jobs and skills. The study adopted a 360° view; looking at societal, technological, economic, ecological and political factors to identify and focus on the 13 most influential and plausible trends impacting the jobs and skills landscape in the UK to 2030.

Figure 1: Trends driving the future of UK jobs and skills



Source: The Future of Work, 2014

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 Table 4, a selection of these trends are examined in more detail and examples of their implications for STEM skills are highlighted.

Table 1: Selected trends shaping the future of UK jobs and skills up to 2030 and the implications for STEM skills

Trend	Description	Examples of implications for STEM skills
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.	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.
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.	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.
Information and Communications Technology (ICT) development and the age of Big Data[1]	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.	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.

[1] "Big Data" refers to ways of handling data sets so large, dynamic and complex that traditional techniques are insufficient to analyse their content.

Trend	Description	Examples of implications for STEM skills
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.	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.
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.	Under these emerging business models processes of so-called open innovation becomes 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.
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.	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
Changing work environments	Businesses are increasingly able to create and disband corporate 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	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.

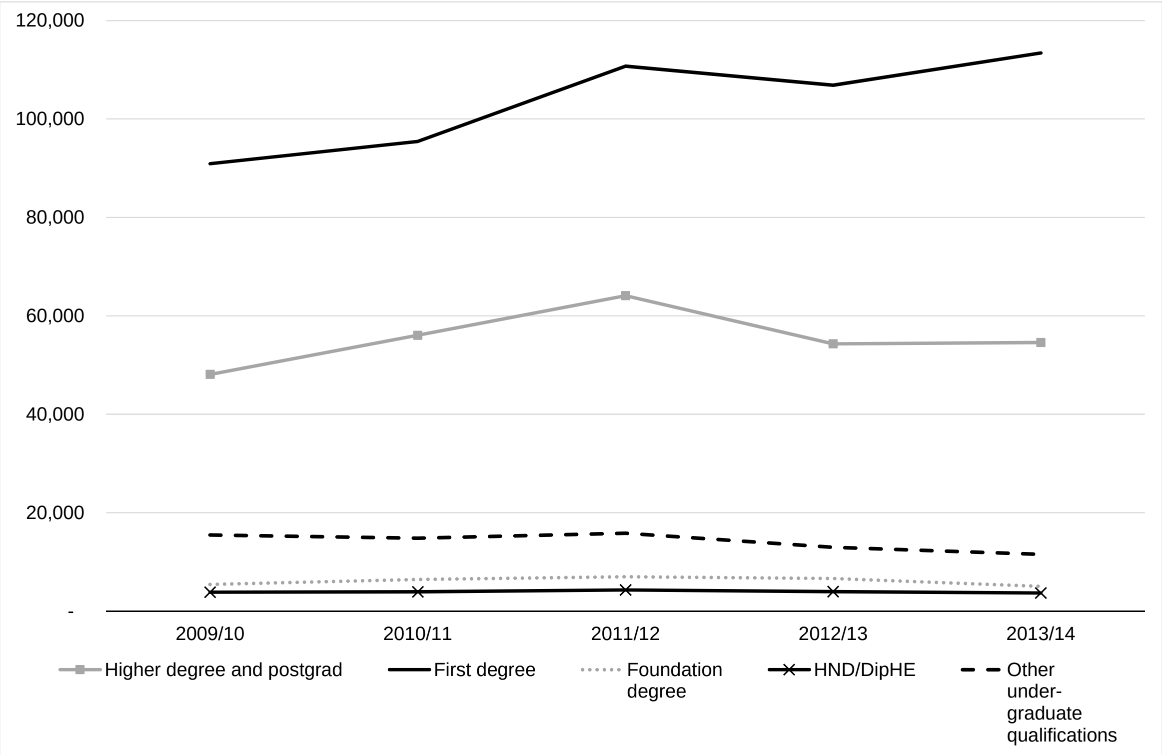
Source: Future of Work, 2014

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.

2.5 The supply of high level STEM skills

The question of whether the supply of high level STEM skills is sufficient to meet the needs of the economy is a focus for lively debate. It is useful to consider the recent trends in the supply of qualified individuals, based on the available data. The following chart sets out the trend over time in the number of higher education qualifications obtained in the UK in STEM subjects by level of study.

Figure 2: HE qualifications in STEM subjects obtained in the UK by level of study



Source: Higher Education Statistics Agency

Note: See for definition of STEM subjects. Chart excludes medicine and veterinary subjects.

If we exclude medicine and veterinary subjects, STEM subjects contributed 188,000 HE qualification achievements during the 2012/13 academic year, around a quarter of total HE achievements.

The majority (60 per cent) of these qualification achievements were at first degree level, followed by 29 per cent at the higher degree and postgraduate level. Other qualifications types, such as foundation degrees and HNDs, which are more likely to have a vocational orientation contribute a small minority of achievements, around 11 per cent of the total when taken together.

Some subjects have a greater prevalence of non-degree HE provision. For example, 29 per cent of achievements in agricultural subjects came from non-degree qualifications, most notably foundation degrees. Computer science and engineering and technology were also slightly above average. On the other hand physical sciences and mathematical sciences are not surprisingly are more heavily dominated by degree programmes.

Between 2009/10 and 2012/13 the total number of STEM HE qualification achievements, based on our definition, increased by 15 per cent, or 22,000 additional qualifications. Achievements at first degree level increased most rapidly, by 25 per cent, whilst foundation degrees, HNDs and other undergraduate qualifications saw a combined decline of 18 per cent. This pattern mirrors the wider picture for HE qualification achievements.

In terms of particular disciplines, biological sciences saw the most rapid growth, of around 27 per cent. Much of this was due to increases in achievements for sports science and psychology. Mathematical sciences also saw strong growth of around 22 per cent, with physical sciences slightly above the STEM average at 18 per cent. Engineering achievements grew more slowly, at only eight per cent, whilst computer sciences saw an actual decline of seven per cent.

Although the academic route represents by far the most significant source of people with high level STEM qualifications, a number of Higher Apprenticeships in STEM-related areas have been available for several years.

According to data from the Skills Funding Agency there were 9,200 starts in total on Higher Apprenticeships during the 2013/14 academic year. Only a small minority (around 10 per cent) of these starts were in STEM-related frameworks, with the IT and Telecoms Professionals sector being by far the greatest contributor of such starts.

2.6 Entry routes into high level STEM occupations

We can build our understanding of the established entry routes into high level STEM occupations by analysing the nature of the formal qualifications held by existing workers in these occupations.

Since, by definition, occupations at the professional level notionally require a qualification at degree level or equivalent it is no surprise that many STEM professional occupations are characterised by having a majority of workers who are graduates. For example, three-quarters or more of workers in each of the scientist occupations hold a degree, with most of the remaining workers holding a non-graduate qualification at level four and above.

Table 2: Qualification profile of high level STEM occupations

SOC unit group	Description	% qualified at degree level	% qualified at non-graduate Level 4+	% qualified at non-graduate Level 4+ as proportion of all high-skilled
1121	Production managers and directors in manufacturing	31%	4%	11%
1123	Production managers and directors in mining and energy	38%	8%	17%
1136	Information technology and telecommunications directors	53%	6%	10%
1255	Waste disposal and environmental services managers	22%	0%	0%
2111	Chemical scientists	76%	9%	11%
2112	Biological scientists and biochemists	79%	6%	7%
2113	Physical scientists	76%	16%	18%
2119	Natural and social science professionals n.e.c.	81%	15%	16%
2121	Civil engineers	63%	8%	12%
2122	Mechanical engineers	40%	6%	13%
2123	Electrical engineers	32%	6%	15%
2124	Electronics engineers	40%	5%	11%
2126	Design and development engineers	51%	8%	14%
2127	Production and process engineers	41%	6%	13%
2129	Engineering professionals n.e.c.	41%	6%	12%
2133	IT specialist managers	47%	7%	12%
2134	IT project and programme managers	50%	11%	19%
2135	IT business analysts, architects and systems designers	53%	10%	16%
2136	Programmers and software development professionals	57%	14%	19%
2137	Web design and development professionals	56%	7%	11%
2139	Information technology and telecommunications professionals n.e.c.	49%	12%	20%
2141	Conservation professionals	81%	1%	1%
2142	Environment professionals	80%	3%	4%

SOC unit group	Description	% qualified at degree level	% qualified at non-graduate Level 4+	% qualified at non-graduate Level 4+ as proportion of all high-skilled
2150	Research and development managers	72%	4%	5%
2461	Quality control and planning engineers	30%	9%	23%
2462	Quality assurance and regulatory professionals	54%	3%	5%
2463	Environmental health professionals	66%	6%	8%
3111	Laboratory technicians	40%	5%	12%
3112	Electrical and electronics technicians	10%	2%	14%
3113	Engineering technicians	14%	3%	20%
3114	Building and civil engineering technicians	30%	4%	13%
3115	Quality assurance technicians	28%	4%	13%
3116	Planning, process and production technicians	19%	4%	17%
3119	Science, engineering and production technicians n.e.c.	23%	3%	12%
3131	IT operations technicians	36%	7%	16%
3132	IT user support technicians	34%	5%	12%
3567	Health and safety officers	37%	4%	9%
5245	IT engineers	24%	6%	19%

Source: Labour Force Survey, 2013

It is perhaps more surprising that large proportions of workers in some professional occupations do not hold a degree. This seems to be particularly the case for engineering professional occupations. Less than a third of electrical engineers and quality control and planning engineers are graduates, whilst fewer than a half of mechanical engineers and electronics engineers are qualified at this level. The relatively low levels of graduate employment in these occupations are not offset to any major extent by non-graduate qualifications at level four and above. In each case less than 10 per cent of workers in the occupation hold such a qualification.

At least notionally, associate professional and technical occupations do not require a degree level qualification. Not surprisingly workers in STEM occupations at this level are less likely to be graduates than their professional colleagues. At the top of the spectrum, 40 per cent of laboratory technicians hold a degree. In contrast, only 10 per cent of electrical and electronics technicians are qualified at this level. Again, non-graduate qualifications at level four and above are comparatively rare; less than two per cent of electrical and electronics technicians hold one.

Therefore, a key conclusion from this analysis is that high level STEM occupations, at both professional and associate professional level, are by no means homogeneous in terms of the pattern of qualifications held by workers. We can infer that occupations with relatively low levels of graduates, such as engineering professionals, have traditionally relied upon non-academic progression routes grounded in the workplace. These same occupations may also provide more fertile ground for higher apprenticeships and other solutions designed to develop high level skills in the workplace.

There is evidence to suggest that this is not a static situation and that recent entrants in any given occupation are much more likely to be graduates or otherwise qualified to a high level. For example, Mason (2012) points to the fact that the graduate share of technician employment has increased steadily, whilst of the proportion of such technicians with a background in employment-based apprenticeship training (as evidenced by possession of Higher National Certificates and Level 3 vocational qualifications) has declined.

Mason also points to continuing positive pay premia attached to Bachelor and higher degree qualifications held by technicians, which suggests that many of the graduates recruited to technician jobs have been useful in meeting rising skill demands. However, he also highlights anecdotal evidence to suggest that employers have some concerns about the mix between graduate and intermediate-level personnel in technician jobs. Graduate recruits are less likely to have the required practical skills and commercial awareness held by older, apprentice-trained technicians and as the latter group move towards retirement there is a need to reconsider the need for work-based training in spite of the substantial costs of financing apprenticeship training.

It is notable that non-graduate qualifications at level four and above, which will often have been undertaken in a vocational and workplace context, do not generally have a significant presence. For most high level STEM occupations fewer than 10 per cent of workers hold such a qualification. In the small number of instances where the incidence is higher than 10 per cent the occupation in question also usually has a high incidence of graduates. Examples include scientist occupations and some IT professional occupations.

2.7 Investment in training

We have considered the issue of new entrants into the labour market but this raises the question of the extent to which employers invest in the skills of workers who are already employed in high level STEM roles. Clearly employers have a critical role to play in ensuring that their workers are equipped with the specific skills and knowledge required to meet business needs.

We have limited labour market data relating to skills gaps and training patterns at a detailed occupational level. The following table compares the likelihood of receiving training in a “core” STEM occupation relative to other occupational groups at the same level of the SOC hierarchy. At the broad level of SOC sub-major groups core STEM occupations are defined as groups 21 and 31.

This analysis, based on the Labour Force Survey, does not claim to present the whole picture. It focuses on the incidence rather than the quality of training. In some circumstances workers might receive training on a less frequent basis but of a relatively high quality and value.

As is well documented, individuals in higher skilled roles (with the exception of managers) are more likely to receive training than those working in lower-skilled occupations. Therefore, at the major group level, professionals and associate professionals have a higher incidence of training than workers in skilled trades, sales, operative and elementary occupations. (The regulatory requirements associated with care jobs drive up the incidence for Caring, leisure and other service occupations).

Table 3: Proportion of workers receiving job-related education or training in the last 3 months

Standard occupational classification Major group Sub-major group	% receiving training
1 Managers, directors and senior officials	21%
21 Science, research, engineering and technology professionals	27%
22 Health professionals	58%
23 Teaching and educational professionals	43%
24 Business, media and public service professionals	36%
2 Professional occupations	40%
31 Science, engineering and technology associate professionals	27%
32 Health and social care associate professionals	46%
33 Protective service occupations	42%
34 Culture, media and sports occupations	17%
35 Business and public service associate professionals	28%
3 Associate professional and technical occupations	30%
4 Administrative and secretarial occupations	22%
5 Skilled trades occupations	17%
6 Caring, leisure and other service occupations	38%
7 Sales and customer service occupations	21%
8 Process, plant and machine operatives	17%
9 Elementary occupations	15%
Average for all occupations	26%

Source: Labour Force Survey

However, the table shows that within this overall pattern that workers in some STEM-focused occupations are less likely to receive training than other workers operating at a similar notional skill level.

This is particularly the case at professional level. Science, engineering and technology professionals (sub-major group 21) are well below the average for the professional major group in terms of the incidence of training and are less than half as likely as health professionals to receive training[2]. Indeed, workers in the STEM professional sub-major group are the least likely to receive training of any of the four sub-major groups at the professional level.

A similar pattern prevails at the associate professional / technical level, although to a less pronounced degree. Science, engineering and technology associate professionals (sub-major group 31) are slightly below the overall average for associate professionals in terms of training incidence but are well below the average for health and social care associate professionals.

Therefore, there is evidence to suggest that workers in STEM professional occupations, in particular, are less likely to receive training than workers in other professional roles. We might infer from this that this occupational area is one of relatively low investment by employers.

2.8 Skills challenges

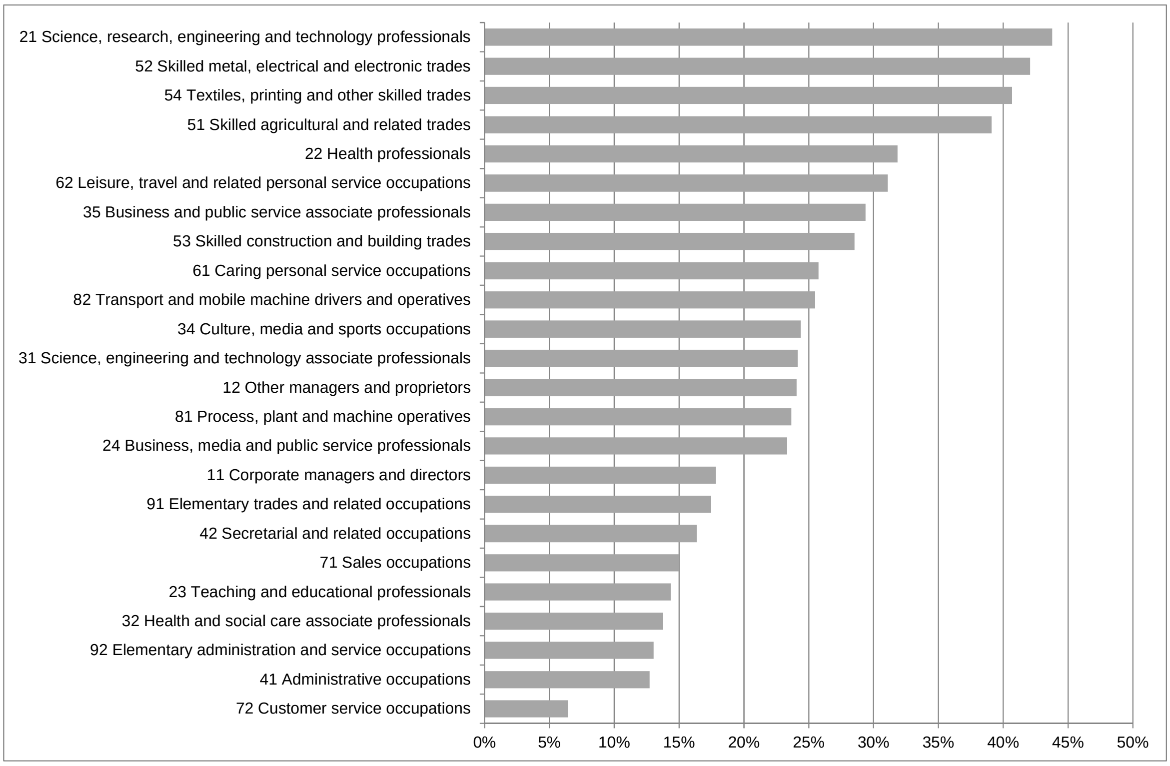
One of the main reasons for the intense policy focus on STEM skills is the widespread concern that employers cannot get the skills they need through the recruitment process. This is supported by strong evidence that STEM occupations face persistent skills shortages[3].

According to the Employer Skills Survey 2013, the Science, research, engineering and technology professionals category (SOC submajor group 21) has the highest ratio of skill shortages to vacancies of any of the 25 occupational sub-major groups. At 43 per cent it is almost twice as high as the overall average of 23 per cent and it is the third highest of the occupational groups in terms of overall volume of shortages (with 13,000). Other STEM-related occupations at the intermediate level also feature highly in the skill shortage ranking, together with health professionals.

---

[2] Clearly, under some definitions health professionals will be classified as STEM occupations but not under the definition we have applied in this report. See chapter 3 for details of the definition.
[3] This section provides a very brief overview of the evidence from the Employer Skills Survey. A detailed analysis of the prevalence of skill shortages in high level STEM occupations is provided in section 4.2.4.

Figure 3: Density of skills shortages by occupation (SOC submajor group)



Source: UK Commission's Employer Skills Survey 2013

Availability of shortage data for England from the Employer Skills Survey for 2007, 2009, 2011 and 2013 allows us to examine persistence over time. The STEM professionals category has been among worst affected occupational areas in terms of skill shortages throughout this period, with density levels well above the overall average in each iteration of the survey. There are concerns that as the UK economy continues on its path of recovery that shortages will intensify.

Skill shortages relating to higher skilled occupations are more likely than average to be connected to a deficiency of technical, practical or job specific skills, or to advanced IT or software skills. 76 per cent of STEM professional (submajor group 21) skill shortages are at least partly attributable to a shortfall of technical, practical or job specific skills (compared with an overall average of 63 per cent for all shortages), whilst 39 per cent are connected to advanced IT or software skills (compared with an overall average of 22 per cent).

The Migration Advisory Committee (MAC) has also undertaken a number of studies to assess occupational skills shortages, in order to inform UK managed migration policy. In its 2013 report it was asked to identify occupations or job titles, skilled to at least NQF level 6[4], facing a shortage of labour that it would be sensible to fill using labour from outside the EEA. In judging whether it is sensible to fill shortages through inward migration the assessment takes account of the economic value provided by the occupations in question.

[4] Broadly corresponding to bachelor's degree level.

The area of greatest concern to the MAC is clearly engineering jobs. MAC point to an increase in the number of engineering job titles on its shortage list in both its latest 2013 list and the previous 2011 list. The newly added job titles relate to the aerospace, railway, electronics, mining, automotive manufacturing and design and the civil nuclear industries.

It is MAC's view that this reflects increasing demand for specialist engineering skills continuing to outstrip potential supply, partly as a result of insufficient joined up activity in this sector on the part of employers and public bodies.

By contrast, a number of job titles in the health sector have been removed from the shortage occupation list, suggesting that the UK is improving its capability to supply the requisite skills thanks to the substantial investment in health training over the last decade.

We have already noted the importance of STEM skills to efforts to rebalance the UK economy. In this regard it is notable that the majority of priority industrial strategy sectors identify a shortage of STEM skills as barrier to growth (CBI, 2013).

2.9 The causes of mismatch

There is an ongoing debate as to whether there is an overall undersupply of high level STEM skills in the UK labour market.

On the one hand the Royal Academy of Engineers (2012) predict a shortage of core STEM workers in the period to 2020, whilst the Social Market Foundation estimates that the UK is facing an annual shortfall of around 40,000 STEM graduates (Broughton, 2013).

Meanwhile, Bosworth (2013) argues that there is no overall shortage of STEM graduates and that such a shortage is unlikely to emerge in most regions and nations in the period to 2020, even under a relatively positive economic scenario. Indeed, his analysis indicates that there is the potential for an oversupply of STEM graduates in a future scenario of low economic growth.

Bosworth estimates an adequate supply of STEM graduates in spite of an increasing dispersion of such graduates beyond traditional Core STEM occupations and sectors. He notes that the share of employed Core STEM degree holders working in Core STEM occupations declined between 2001 and 2010, as the number of such degree holders grew faster than employment in the relevant occupations. A similar point is picked up by Semta (2010) who highlight the low proportion of STEM graduates being recruited by Semta employers, arguing that this is likely to be due to a mixture of the perceived quality of applicants and the image of Semta's sectors to these graduates.

If we accept that there is an overall balance between supply and demand of individuals with high level STEM skills and knowledge, how do we then explain the skill shortages reported by employers? It seems that these shortages relate to specific recruitment difficulties in some STEM-related areas where employers report insufficient UK candidates of suitable quality. This fits with our general understanding of skill shortages: that they are relatively few in number and in concentrated pockets, but with the potential to disrupt business performance to a disproportionate extent.

Employer interviews conducted by Bosworth indicate that employers are concerned about a shortage of graduates with the right degree content. Employers perceive that a very limited number of universities give a rigorous foundation in specific disciplines that are required and that some have cut back on equipment and laboratories, meaning that graduates have less hands-on experience in specialised disciplines like fluid dynamics. Similarly, some commentators argue that the deficit in graduate quality is partly due to less demanding study programmes and the emergence of new subjects, such as sports science (House of Lords, 2012).

In addition to a lack of suitable STEM skills, there are also “broader concerns about a lack of well-rounded candidates with technical skills, broader competencies, such as mathematical capability, and practical work experience.” This qualitative evidence also suggests particularly acute shortages of experienced STEM staff with several years of exposure to the workplace and also problems in retaining these experienced workers.

Commuting patterns may play a part in shortages of STEM skills in some areas of the country. According to Bosworth (2013) interviews with STEM employers consistently indicate that London acts as a magnet to STEM workers at the expense of other parts of the country and may help to explain shortages of skilled workers in some areas. There is also a concern that London is attracting the best graduates. This is supported by an analysis of the commuting data by Bosworth which points to a net gain of 87,000 Core STEM workers for London and substantial net losses for the South East, East of England and East Midlands. An analysis of trends in commuting patterns suggests that London is likely to see a continuing increase in its net gain of workers.

3 Identifying high level STEM occupations

Chapter Summary

- In this chapter we describe the approach used to identify high level STEM occupations and present a long-list and final list of occupations.
- There is a reasonable consensus on what constitutes high level STEM skills and knowledge, at least when expressed in terms of the disciplines studied within higher education.
- A range of differing approaches have been used to identify sectors and occupations with a significant requirement for STEM skills – from the selection of relevant occupational and sectoral categories using judgment, to more data-driven approaches.
- Our approach seeks to identify occupations that have a significant requirement for high level STEM skills and for which the higher apprenticeship pathway is a relevant one.
- The first stage of the approach to identifying occupations involved an objective analysis of labour market data, which provides a long-list of 61 occupations. We believe that this results in a good separation between STEM and non-STEM occupations.
- This long-list was then modified on the basis of judgment. For example, medical and teaching occupations were excluded on the grounds of relevance to the present exercise. All such changes are documented below.
- These adjustments left a final list of 38 occupations, which provides the basis for the next stage of the review.

3.1 Introduction

A key step in assessing the labour market need associated with high level STEM occupations is to arrive at a definition of the occupations which should be included in the analysis. In this chapter we set out our approach, which is based on both data analysis and judgment, and present the list of occupations which we took forward to the modelling stage of the review process.

3.2 Defining STEM skills

What do we mean by STEM skills and how can definitions of STEM skills be operationalised in an analytical context? In the following section we review the available literature to examine how these questions have been addressed in the past.

There is a reasonably strong and broad consensus as to what constitutes STEM-related skills and knowledge at least in terms of the specific academic disciplines that fall within the scope of science, technology, engineering and mathematics.

Under this approach holding particular qualifications is generally used as a proxy for 'skills'. This is imperfect as people may have developed STEM competencies outside their study for qualifications. However, this proxy is typically used in the STEM literature and terms like 'STEM skills' and 'STEM subjects/qualifications' tend to be used interchangeably.

In practical terms, subject classifications, particularly those developed for the higher education sector, allow STEM disciplines to be categorised in a discrete and understandable way. This is demonstrated by Table 4 which shows the clear split between STEM and non-STEM subjects. A number of leading reports use this subject classification to identify STEM graduates, including BIS in its report on the demand for STEM skills and CIHE in its report on STEM demand.

Table 4: Higher education subject areas by STEM status

Subject group	Categorisation
(1) Medicine & dentistry	**STEM**
(2) Subjects allied to medicine	**STEM**
(3) Biological sciences	**STEM**
(4) Veterinary science	**STEM**
(5) Agriculture & related subjects	**STEM**
(6) Physical sciences	**STEM**
(7) Mathematical sciences	**STEM**
(8) Computer science	**STEM**
(9) Engineering & technology	**STEM**
(A) Architecture, building & planning	Non-STEM
(B) Social studies	Non-STEM
(C) Law	Non-STEM
(D) Business & administrative studies	Non-STEM
(E) Mass communications & documentation	Non-STEM
(F) Languages	Non-STEM
(G) Historical & philosophical studies	Non-STEM
(H) Creative arts & design	Non-STEM
(I) Education	Non-STEM

Source: Higher Education Statistics Agency

This makes the task of assessing the supply of people from higher education holding STEM qualifications a relatively straightforward task (see section 2.5 above).

A more painstaking approach has been required to identify STEM qualifications delivered through the further education and skills system. A series of *FE and Skills STEM Data* reports have been produced, which analyse the Learning Aims Database, the Individual Learner Record and other Further Education. The most recent report (Harrison, 2012) identified 15,000 STEM qualifications, which accounted for 25 per cent of all funded qualification achievements through the FE and skills system in the 2010/11 academic year. To be classified as STEM within this approach, qualifications are required to have learning outcomes that are deeply rooted in science, mathematics or engineering and/or are of a ‘technical’ or ‘technology-application/use’ nature. They may also be classified as STEM if the qualification is judged to provide a degree of learning that will aid progression in S, T, E or M.

However, for the purposes of this review we are primarily interested in demand for STEM skills and the particular types of STEM skill which demonstrate the greatest need. In order to assess the demand for STEM skills in the labour market the typical approach that is adopted is to seek to identify those occupations and industry sectors that have a significant requirement for STEM skills. It is then possible to apply indicators of demand relating to employment, vacancies and pay.

Approaches vary with regard to the methods used to identify STEM-intensive occupations and industries; ranging from the application of expert knowledge and judgment in selecting relevant occupational and sectoral categories, through to the use of harder empirical methods. The approaches used by a selection of leading studies are considered below. However, as Bosworth notes “the issue of precisely where to draw the line between STEM and non-STEM never goes away” and is perhaps not fully resolvable.

In his assessment of Technician employment in the UK economy Mason (2011) identified SET (science, engineering, technology) occupations as those in which the application of scientific, engineering and/or technological skills and knowledge is central to the job-holder’s work. The process of identification involved the application of judgment to the list of occupational categories contained with the Standard Occupational Classification.

This judgment-based approach is perhaps the most common and is also used in BIS (2009) to identify scientific occupations and by the Institute for Employment Research as the basis for its projections of demand for STEM graduates (CIHE, 2009).

In order to assess supply and demand for high level STEM skills Bosworth (2013) uses empirical methods to identify occupations and sectors that have an intensive requirement for individuals holding qualifications at degree level and above in STEM subjects. The definition of STEM subjects is a standard one reflecting the discussion above. Occupations and sectors are considered to fall within the STEM category if they reach particular thresholds in terms of both the density of graduates employed (STEM graduates as a proportion of total employment) and the proportion of the total number of the corresponding STEM group employed within the economy.

A number of the leading studies differentiate between different types of STEM skill and occupation, according to the purpose and scope of the study. For example, Bosworth separates out occupations in the medical sphere from what he terms “core” STEM occupations. Mason excludes occupations that are mathematics-based (such as actuaries and statisticians) rather than science, technology or engineering based from his review of technicians.

3.2.1 STEM occupations

The concept of an occupation is a key mechanism for understanding the demand for skills in the workplace, particularly when thinking about apprenticeships. It encapsulates the key dimensions of skill level and skill content (specialisation) with reference to the skills required to do a job (ONS, 2010).

It has been argued that a defined occupation should be the foundation for all apprenticeships to ensure that there is a link to occupational competency and it has been further argued that recent developments in policy and practice have eroded this link (Gatsby Foundation, 2013).

It is because occupation is the pre-eminent indicator of a job’s skills level / content and because it is linked at a conceptual level to apprenticeships that we have used it as the organising framework for our assessment of labour market need.

3.3 General approach to defining STEM occupations

Drawing on the literature, we define STEM occupations as those that require knowledge and skills in science, technology, engineering and mathematics.

We have used the Standard Occupational Classification (SOC) 2010 at the 4-digit unit group level as the basis for our analysis, since this offers a detailed, common and consistent framework and is the occupational classification used for key statistical datasets.

Box 1: The Standard Occupational Classification

The Standard Occupational Classification (2010) assigns 27,000 known job titles to 369 occupational unit groups. Its purpose is to provide a consistent means of classifying jobs. Jobs are defined as a set of tasks or duties to be carried out by one person and are recognised by the associated job title.

Under SOC, jobs are classified into groups according to the concept of ‘skill level’ and ‘skill specialisation’.

Skill level is defined with respect to the duration of training and/or work experience recognised as being normally required in order to perform the activities related to a job in a competent and efficient manner.

Skill specialisation is defined as the field of knowledge required for competent, thorough and efficient conduct of the tasks. In some areas of the classification it refers also to the type of work performed (e.g. materials worked with, tools used, etc.).

The latest version of the Classification, SOC2010, consists of a hierarchical structure with four nested tiers:

- 9 Major groups – top-level, broad definitions of occupation, providing the first digit of the SOC2010 code number
- 25 Sub-major groups – second-level definition of occupation, providing second digit
- 90 Minor groups – third-level definition, providing third digit
- 369 unit groups – lowest, most detailed definition of occupation, providing the complete four-figure SOC2010 code.

The 25 sub-major groups can be assigned to four broad skill levels, ranging from a basic level, at which jobs simply require a general education typically associated with compulsory schooling, through to professional and high level managerial positions that require a degree or equivalent period of relevant work experience.

SOC is used to classify official statistics relating to employment and the labour market, including:

- Employment; with regard to main job, second job, previous job (Labour Force Survey, Census of Population)
- Earnings and hours worked (Annual Survey of Hours and Earnings).

In addition to official statistics SOC is also used to classify data within a range of other surveys and studies. For example:

- Vacancies, hard-to-fill vacancies and skill shortages (UK Commission's Employer Skills Survey)
- Projected future employment (*Working Futures*)
- Previous job and job sought by Jobseeker's Allowance claimants (Jobcentre Plus administrative system).

The Migration Advisory Committee also uses SOC as the basis for its analysis of the labour market which is used to inform its recommendations around work immigration.

For further details see the ONS website.

It is possible to identify "core" STEM unit groups from the SOC framework on the basis of judgment, but we have widened this, using objective analysis to identify a long-list of occupations that need higher level STEM skills and knowledge.

In pursuing this approach we have sought to move beyond the most well-known STEM occupations and identify newer emerging roles due to the changing pattern of employer demand for STEM skills in the labour market.

Our approach 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.

However, since the purpose of this review is to inform thinking within a defined policy context we have also applied judgment to the results of our objective analysis and taken on board feedback from policy colleagues concerning the preferred scope of the analysis. These judgments are documented and explained below.

3.3.1 Defining STEM occupations: creating the longlist

We have identified STEM occupations on the basis of a) objective analysis and b) application of judgment to the SOC framework using the wider evidence base.

In taking forward the first stage of the objective analysis, we implemented the following approach to identifying occupations that require STEM knowledge and skills.

1. Using data from the Labour Force Survey we derived the proportion of workers in each occupation who are STEM graduates (see Box 1 for our definition of STEM subjects using the Labour Force Survey subject classification).

2. We developed a combined index for Numeracy and Problem Solving based on indicators of skills use contained in the UK Skills and Employment Survey. This then provides a single measure of STEM-relevant skills use.
3. Using the two scores from 1 and 2, we ran a k-medians cluster analysis where k=2, in order to classify each occupation into STEM and non-STEM.
4. We checked and applied judgment to the results.

In assessing demand for high level STEM skills we have used the existing prevalence of STEM graduates as one of our two indicators. We believe that this is a reasonable measure but not a perfect one. The presence of STEM graduates in an occupation is unlikely to be solely due to demand from the employer for STEM skills. It may also reflect the fact that relatively high wages are on offer, which attract capable people who happen to be STEM graduates. Ideally we would like to base our approach purely on measures of the actual application of STEM skills in the workplace by occupation. Our indicator from the UK Skills and Employment Survey provides this in a partial way i.e. it does not cover the full range of STEM competencies. There are no alternative sources of such data for the UK, hence the need to use a combination of two indicators.

It was originally intended to include a further indicator relating to the proportion of workers who hold a vocational qualification in a STEM subject at level 4 and above. Clearly, in our definition of high level STEM occupations we are interested in occupations within which high level skills obtained through a vocational rather than academic pathway predominate.

Although this analysis is theoretically possible using the Labour Force Survey we found the available data to be insufficiently robust to provide an accurate picture.

Box 1: Definition of STEM disciplines using Labour Force Survey subject categories

(3) Biological Sciences
(4) Veterinary Science, Agriculture & related subjects
(5) Physical Sciences
(6) Mathematical and Computer Sciences
(7) Engineering
(8) Technologies

NB: We included medical subjects within our STEM subjects even though we intended to exclude medical occupations from the subsequent modelling work. This was in order to simplify the process of validating the results of the cluster analysis.

3.4 The initial longlist of occupations

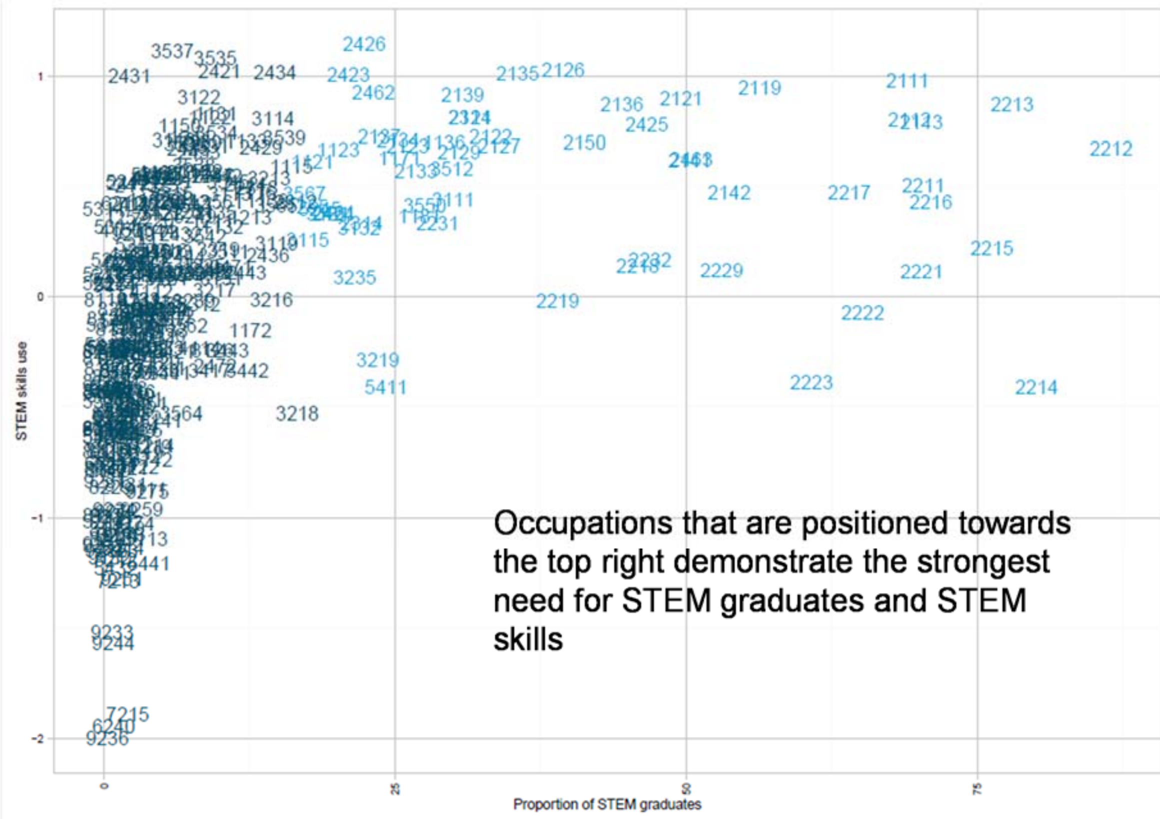
The approach described above produced a clear separation between STEM and non-STEM occupations (see chart below).

61 (out of the total of 369) SOC unit groups were identified as STEM occupations at the initial stage. See Appendix A for the full longlist of the occupations and their STEM / non-STEM categorisation.

The approach also proved to be largely successful in identifying occupations in line with prior expectations. . This shows, for example, that all unit groups falling within sub-major group 21 (science, research, engineering and technology professionals) are assigned to the STEM category. The major exception to this is technician roles. A number of these are not classified as STEM occupations. We believe that this may be partly due to the fact that we were not allowed to take account of the prevalence of higher level vocational qualifications within these occupations because of a lack of usable data on vocational qualifications at level 4+.

We then made a series of judgments, which led to changes in the list. Some occupations were excluded and some added. The nature of these changes and the rationale for them is set out below.

Figure 4: Cluster analysis of occupations: STEM vs non-STEM



3.5 Refining the long-list

Our approach to defining relevant high level STEM occupations takes account of an element of judgment as well as the objective analysis described previously. This involves the exclusion of some occupations that feature on the long-list, the inclusion of some that do not feature and the retention of some occupations that we feel merit inclusion even if this is debatable.

The need to apply judgment reflects a number of considerations. The cluster analysis is a useful starting point but does not claim to be perfect. We have already noted the lack of an indicator relating to higher level vocational qualifications. There is a need to make adjustments to take account of such weaknesses. There is also a need to take account of the policy context. Although health occupations at professional and associate professional levels demonstrate a strong requirement for STEM skills they draw on their own development pathways outwith apprenticeships and other work-based development routes that are the focus of this review.

We feel that it is acceptable practice to make these adjustments providing that they are made explicit as we have done below. Furthermore the judgments we have made at this stage do not close off further debate about what constitutes a high level STEM occupation.

The occupations that have been excluded from the assessment / modelling process, are as follows.

- There is one clear “false positive” within the results in the form of the Officers in armed forces category, which has been excluded.
- We have excluded health / medical occupations on the grounds that they are not relevant to the present exercise. The higher apprenticeship route is not generally applicable to these occupations. In this context it should be noted that related biological scientist occupations fall within a separate category and are considered as part of the review.
- Teaching occupations have been excluded, again on grounds of relevance to this exercise.
- In common with some other studies (such as Mason, 2012) we have excluded occupations which are mathematics-based but which are not explicitly science, engineering or technology-based. This includes professionals engaged in business analysis and statistical / actuarial work.
- Similarly, Aircraft pilots unsurprisingly demonstrate a significant requirement for STEM skills but the occupation appears to be qualitatively different to the “core” STEM occupations which we take forward to the modelling work and has been excluded.
- Two occupations with estimated employment below 10,000 have been excluded: Weavers and knitters and Conservation and environmental associate professionals. This is because the available statistical data are not sufficiently reliable to support their inclusion in the modelling work.

Based on judgment a number of occupations not identified through the objective analysis have been **added**:

- A number of technician unit groups (within sub-major group 31), are not classified as STEM occupations using our approach, due we believe to lack of usable data relating to higher level VQs. Since on an intuitive level they seem to be core STEM occupations for the purposes of this review, we have taken them forward to the modelling stage.

We have also made judgments about **retaining** certain occupations, although their inclusion could be debated:

- Occupations falling within the corporate management sub-major group have been retained (e.g. production managers in manufacturing). It is perhaps debatable whether an apprenticeship route is applicable to roles at this level. Nonetheless, the occupations in question fit within our definition of a STEM occupation since STEM skills are a significant requirement for doing the job.
- We have retained residual unit groups (ending in “9”) that draw together miscellaneous jobs “not elsewhere classified” by other unit groups. Since these categories comprise a disparate range of jobs, their value for this exercise is debatable. However, they have been included for the purposes of further exploration and discussion.

3.6 The final list

Taking into account the series of judgments set out above, the final list of STEM occupations comprises 38 SOC unit groups (4-digit categories)

These unit groups are nested within 11 minor groups (3-digit categories) which we use as “job families” in order to present our contextual information and assessment of labour market need in a more manageable way.

The list is set out below.

Occupation	**Job family**
Production managers and directors in manufacturing (1121)	Managers (inc. production managers)
Production managers and directors in mining and energy (1123)	Managers (inc. production managers)
Information technology and telecommunications directors (1136)	IT professionals
Waste disposal and environmental services managers (1255)	Managers (inc. production managers)
Chemical scientists (2111)	Scientists
Biological scientists and biochemists (2112)	Scientists
Physical scientists (2113)	Scientists
Natural and social science professionals n.e.c. (2119)	Scientists
Civil engineers (2121)	Engineering professionals
Mechanical engineers (2122)	Engineering professionals
Electrical engineers (2123)	Engineering professionals
Electronics engineers (2124)	Engineering professionals
Design and development engineers (2126)	Engineering professionals
Production and process engineers (2127)	Engineering professionals
Engineering professionals n.e.c. (2129)	Engineering professionals
IT specialist managers (2133)	IT professionals
IT project and programme managers (2134)	IT professionals
IT business analysts, architects and systems designers (2135)	IT professionals
Programmers and software development professionals (2136)	IT professionals
Web design and development professionals (2137)	IT professionals

Occupation	**Job family**
Information technology and telecommunications professionals n.e.c. (2139)	IT professionals
Conservation professionals (2141)	Environment / conservation professionals
Environment professionals (2142)	Environment / conservation professionals
Research and development managers (2150)	R&D managers
Quality control and planning engineers (2461)	Quality professionals
Quality assurance and regulatory professionals (2462)	Quality professionals
Environmental health professionals (2463)	Quality professionals
Laboratory technicians (3111)	Science, engineering, production, technicians
Electrical and electronics technicians (3112)	Science, engineering, production, technicians
Engineering technicians (3113)	Science, engineering, production, technicians
Building and civil engineering technicians (3114)	Science, engineering, production, technicians
Quality assurance technicians (3115)	Science, engineering, production, technicians
Planning, process and production technicians (3116)	Science, engineering, production, technicians
Science, engineering and production technicians n.e.c. (3119)	Science, engineering, production, technicians
IT operations technicians (3131)	IT Technicians
IT user support technicians (3132)	IT Technicians
Health and safety officers (3567)	Health and safety officers
IT engineers (5245)	IT engineers

4 Profile of the high level STEM occupations

Chapter Summary

- In the previous chapter we identified occupations with a strong requirement for high level STEM skills. We now go on to profile the key characteristics of these occupations. This provides context to our subsequent assessment of labour market needs by occupation. These contextual insights are also useful in informing our thinking about how practical action to address skill needs should be undertaken.
- Our high level STEM occupations have total employment of 2.8m jobs. IT professionals is by far the largest job family, followed by engineering professionals and managers. These groups also make the largest contributions to projected net job growth and projected recruitment needs.
- The greatest prevalence of skill shortage vacancies is estimated to be for engineering professionals, followed by IT professionals and then Science, engineering and production technicians.
- In line with expectations, women account for less than a quarter of total jobs in these occupations and have a particularly low representation in engineering professional and IT professional job families as well as among managers.
- High level STEM employment is widely distributed and is increasingly becoming service-sector based, with future job growth expected to be focused on areas like **Professional services** and **Information and communication.** This raises an issue about how standards and frameworks should be contextualised to fit with these settings and how employer networks might best be organised to develop them.
- Employment in high level STEM occupations is weighted towards London and the South East but is important in all UK nations and English regions. Specific regional and local employment specialisms need to be assessed in order to define priorities at these levels.
- A disproportionate share of high level STEM vacancies (relative to employment) are found in the Professional services sector, suggesting that the sector plays an important role in job creation.

4.1 Introduction

In the previous chapter we identified the high level STEM occupations that provide the basis for this review. Before moving on to a detailed assessment of the labour market needs associated with those occupations we use this chapter to profile the key characteristics of the selected occupations.

For reasons of consistency the profiling analysis draws on indicators and sources used within our core labour market model. These are described, below, in section 5.2. In particular, Working Futures is used as the source of data for current employment in the high level STEM occupations, rather than the most recent Labour Force Survey data. This provides for consistency between current employment estimates and projections of future employment that play a central role in the labour market model.

We extend the analysis beyond that covered by the core model presented in chapter 5 by considering additional dimensions, including distribution of employment by sector and region and prevalence of high level STEM skill shortages by region.

Rather than using the 38 detailed occupations as our main framework, we seek to make the analysis presented in this chapter more digestible by using the 11 job families introduced in section 3.6. These families are also employed in a similar way for the assessment of labour market need contained in the next chapter. More detailed data for the 38 unit groups is provided in Appendix B.

4.2 The key characteristics of the job families

In the following section we explore the relative position of our STEM job families with reference to employment, growth prospects, recruitment need, skill shortages and average pay levels.

4.2.1 Employment

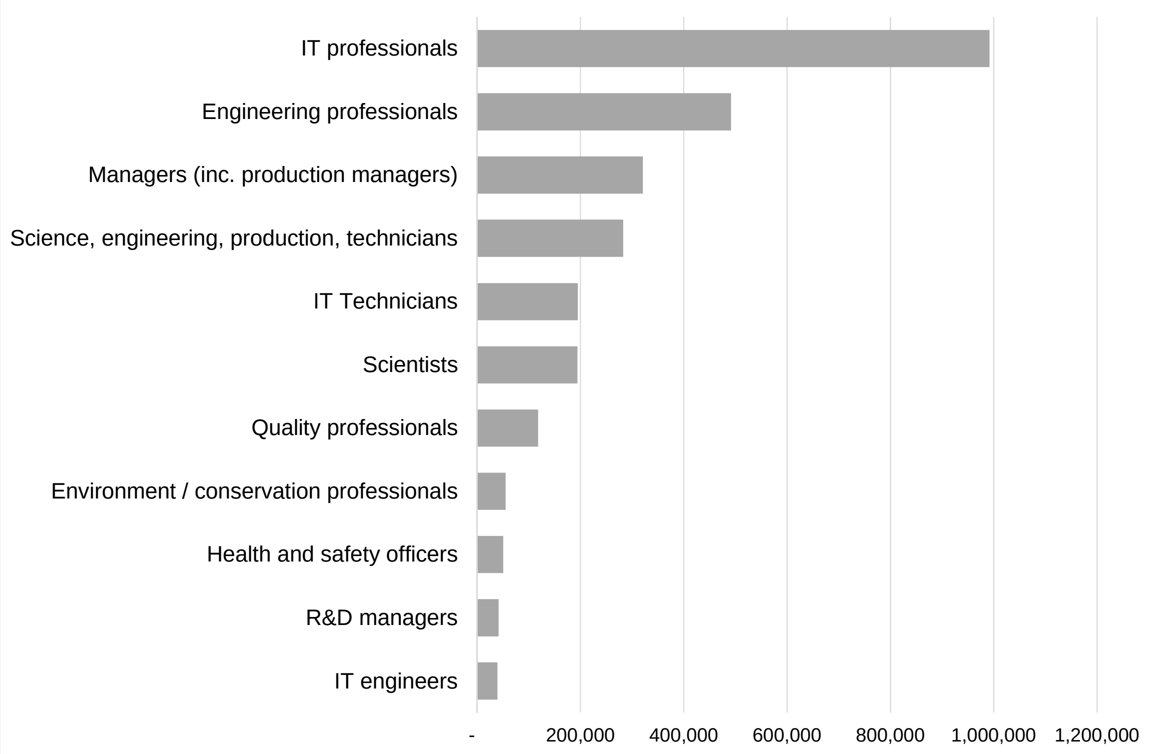
The high level STEM occupations we have identified contribute total employment of 2.8m jobs[5].

IT professionals is easily the largest of the job families, followed by engineering professionals and then managers and STEM technicians. 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.

There are close to 1 million IT professional jobs in the UK, accounting for more than a third of total jobs in high level STEM occupations. This is twice the proportion of any of the other job families under consideration. The largest unit groups within IT professionals are Programmers and software developers and IT specialist managers, each of which accounts for more than 200,000 jobs.

[5] Our full "long-list" of high level STEM occupations, set out in appendix A, accounts for more than 5m jobs.

Table 5: Level of UK employment within high level STEM job families, 2012



Source: Working Futures

There are close to 500,000 engineering professional jobs, representing 18 per cent of total high level STEM employment. The largest occupational unit groups within this family are estimated to be the residual category of Engineering professionals n.e.c. (around 100,000 jobs), mechanical engineers with more than 90,000 jobs and civil engineers with more than 80,000.

Technicians in science, engineering and production contribute 10 per cent of total high level STEM employment, around 280,000 jobs. The most significant occupations in employment terms are Engineering technicians (with around 80,000 jobs) and Laboratory technicians (with around 75,000 jobs). Several technician occupations are relatively niche. For example, it is estimated that there are around 20,000 jobs for quality assurance technicians and around 15,000 building and civil engineering technician jobs.

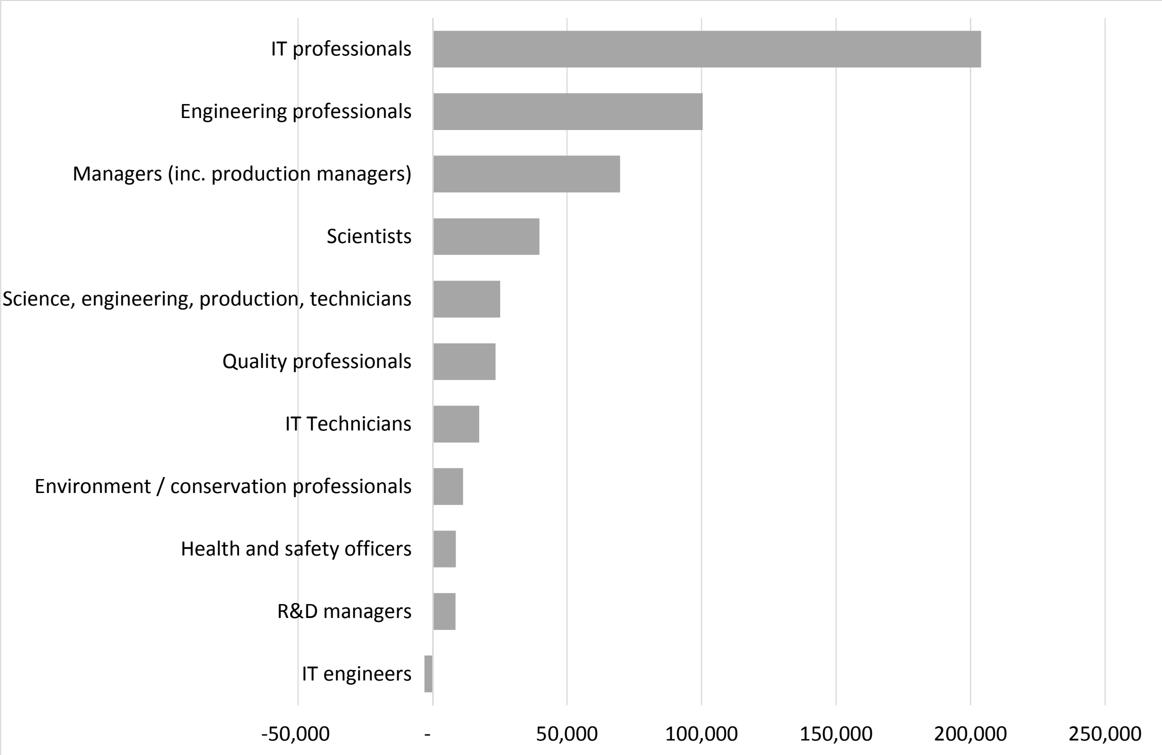
4.2.2 Projected net growth in employment

Data from Working Futures enables us to examine prospects for net growth. Since the underlying official data are not sufficiently robust to support the development of projections at the 4-digit unit group level, our projections of employment growth rates relate to the sub-major group level (2-digits). These rates are then applied to the more detailed occupational categories (see the Working Futures Technical Report [Wilson et al., 2014b] for more detail concerning the approach used).

Corporate management occupations are projected to see the most rapid rate of growth between 2012 and 2022, of more than 20 per cent, closely followed by professional level occupations, including engineering professionals and IT professionals. Technician level occupations have a much slower projected growth rate of nine per cent (although this is still higher than the average rate of six percent which is projected for UK employment as a whole).

Since, virtually all of the occupational areas under consideration are expected to see at least some growth, this means that the size of the opening stock of employment is a key determinant of growth prospects. Therefore, the projected pattern of net job growth broadly reflects the profile of employment. IT professionals represent the largest contributor of additional jobs over the period, with projected net growth of around 200,000 jobs. However, the slightly lower projected growth rate for technician occupations pushes both technician job families lower down the ranking.

Table 6: Projected net change in UK employment by high level STEM job family, 2012-2022

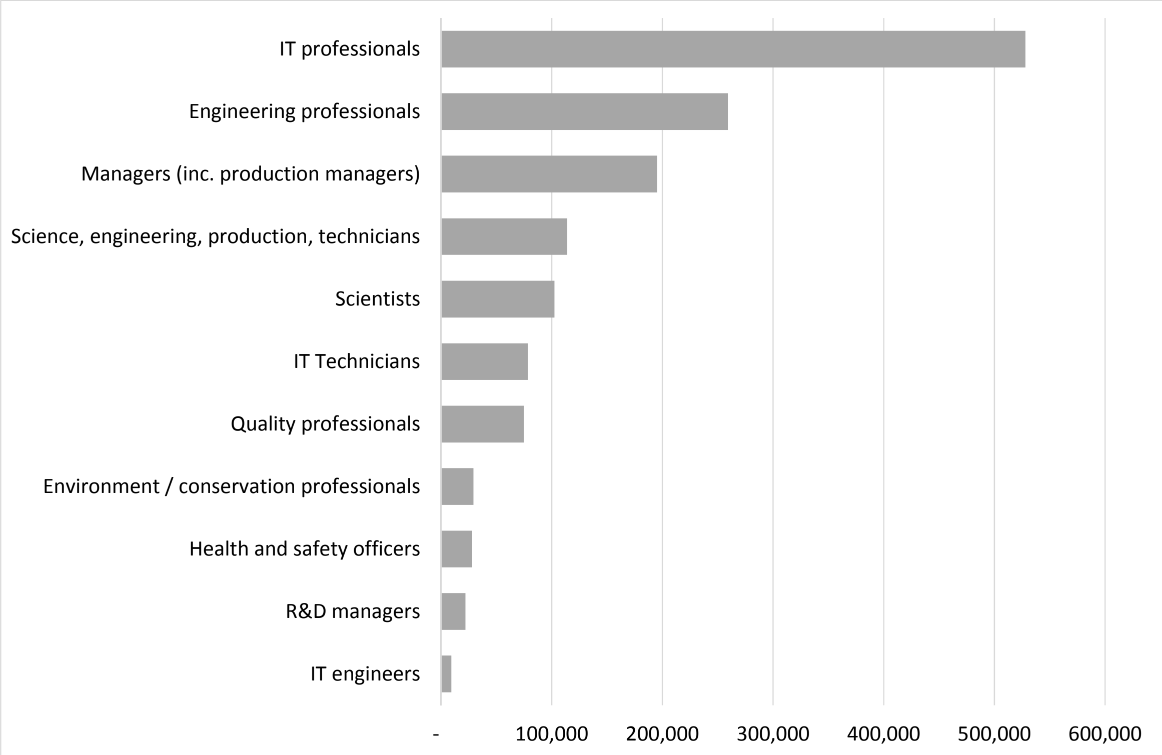


Source: Working Futures

4.2.3 Projected job openings

Here we consider the number of job openings that we expect to see in an occupation, taking into account both net growth and replacement demands. This is the core indicator of the future requirement for new recruits in an occupation. As with projections of net job growth, estimates of future job openings are calculated at the sub-major group level. Again, the opening stock of employment measured in absolute terms is a key determinant of future recruitment needs; meaning that occupational “hierarchy” in respect of job openings is similar to that for employment. However, projected replacement rates vary by occupation, reflecting factors like age structure of employment. Replacement rates for technician occupations are relatively high meaning that the position of technician job families is elevated in this analysis.

Table 7: Projected UK job openings by high level STEM job family, 2012-2022

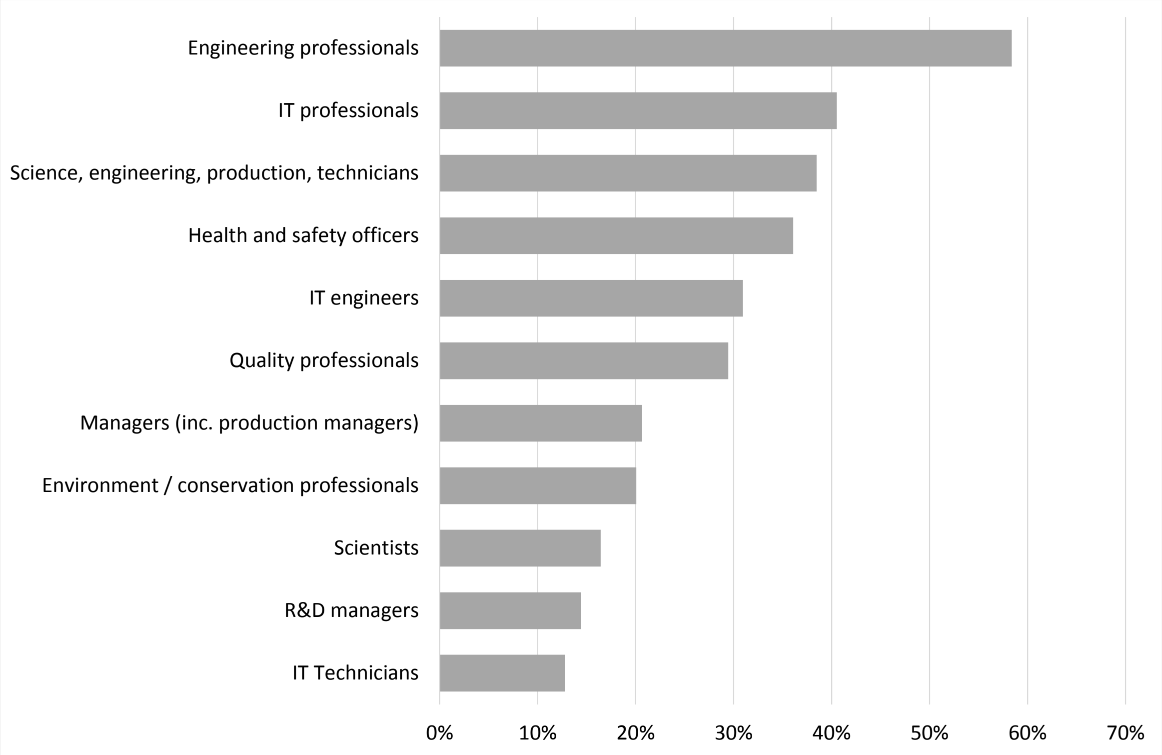


Source: Working Futures

4.2.4 Skill shortages

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. Close to 60 per cent of vacancies relating to occupations in this family are difficult to fill due to a lack of skilled candidates. For mechanical engineers, for example, this proportion rises to close to 70 per cent. 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.

Table 8: Skill shortage vacancies as a proportion of vacancies by high level STEM occupation, UK

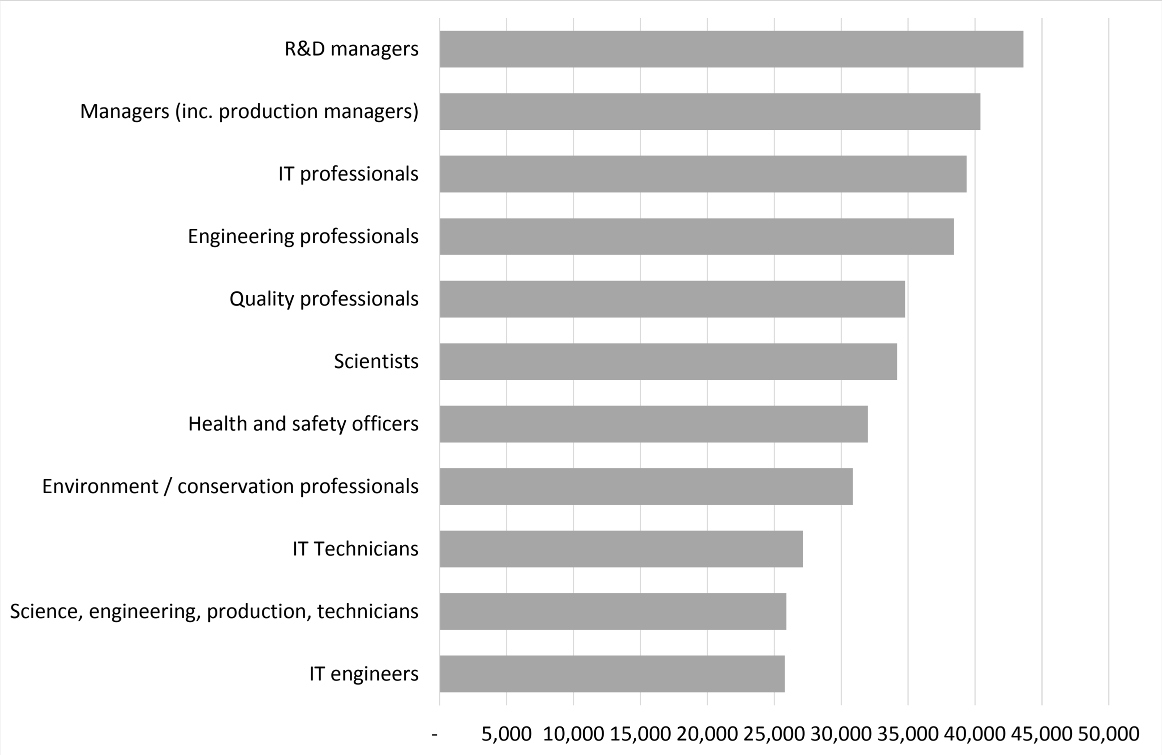


Source: UK Commission Employer Skills Survey, 2013

4.2.5 Median pay

Levels of pay associated with an occupation are of interest both because they reflect the level of reward that can be expected by an individual workers but also as a reflection of the contribution to productivity made by a given occupation.

Figure 5: Gross median annual pay by high level STEM occupation (£); UK



Source: Annual Survey of Hours and Earnings, 2013

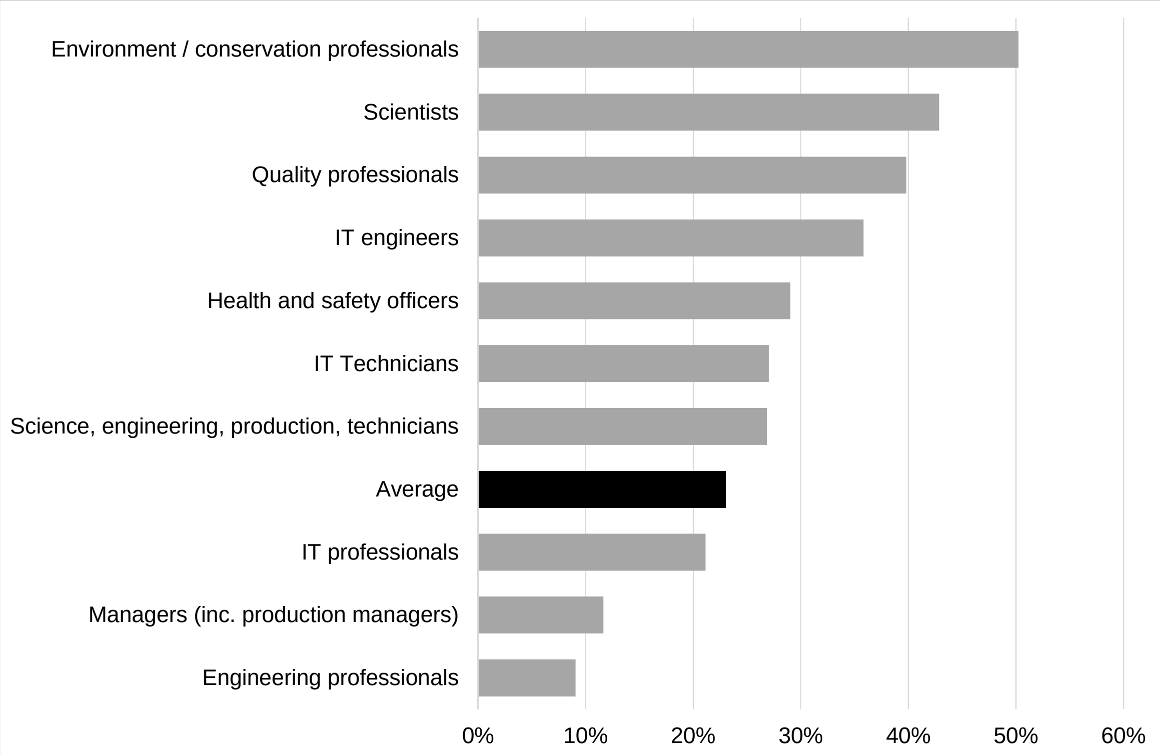
The profile of median pay broadly reflects the occupational hierarchy, with management and professional occupations attracting higher pay than technician and skilled trades roles. The median level of pay for scientists is somewhat below that for IT professionals and engineering professionals.

4.3 Gender and status

Gender segregation of employment by occupation is a well-documented feature of the UK labour market and has been a particular focus of concern in the context of STEM jobs. For example, there are a number of initiatives designed to address the under-representation of women in engineering and IT jobs.

Data from Working Futures confirms that women are significantly under-represented across our high level STEM occupations, accounting for less than a quarter of total employment. It is within the largest job families that women are under-represented to the greatest extent. Women are estimated to hold less than 10 per cent of jobs for engineering professionals, a slightly higher proportion of management jobs and around a fifth of IT professional jobs.

Figure 6: Female employment as proportion of total by high level STEM job family, 2012



Source: Working Futures

It is in the smaller job families that women have a higher representation. They hold a slight majority of jobs in the Environmental / conservation professionals job family and are close to parity in terms of scientists. Women have an above average presence in the science, engineering, production technician family but this is principally due to their share of employment in the laboratory technician occupation. Elsewhere within this job family their representation is thin; less than 10 per cent in the Engineering technician occupation, for example.

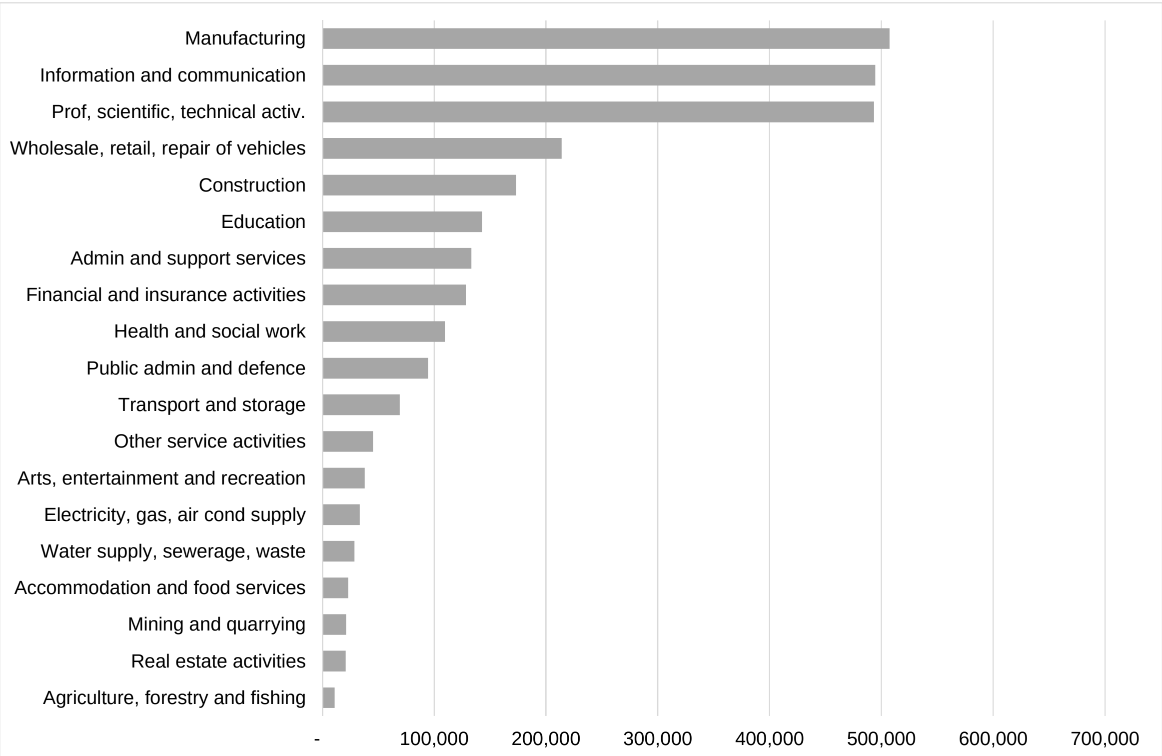
4.4 Sectoral patterns

In this review we have used occupation as the main framework for our analysis. However, much of the practical activity that is being undertaken to address skill needs, including the development of apprenticeships, is organised along industry sector lines. Industrial Partnerships are the key mechanism for bringing employers together around the skills agenda, whilst the Government's industrial strategy also has a strong focus on key sectors.

As previously noted, around 2.8m people are employed in the high level STEM occupations we have identified. Figure 7, below, shows how this employment is distributed across broad industry sectors. It indicates that employment in these roles is widely spread across the economy, but with several notable concentrations.

- Manufacturing, the sector that is most closely associated with STEM skills in many minds, accounts for the largest share of high level STEM employment of any of the sectors, at around 18 per cent of the total (just over 500,000 jobs).
- However, two other sectors account for similar, if slightly smaller, shares: Information and communication and Professional, scientific and technical activities (Professional services).
- The Information and communication sector comprises many core activities relating to information technology, including telecommunications, computer consultancy and information services (e.g. data processing, hosting).
- Professional services includes activities that one would expect to have a strong requirement for STEM skills, including scientific R&D, engineering design / consulting, technical testing / analysis, environmental consulting.

Figure 7: Distribution of UK employment in STEM occupations by industry sector (SIC section)



Source: Working Futures

Looking at the sectoral distribution of employment within our job families (Figure 8), the pattern is more complex, although the three leading sectors highlighted above feature highly for most families. For example:

- Employment for production managers, engineering professionals and STEM technicians is weighted towards manufacturing, although not overwhelmingly so.

- Employment in IT-related occupations at both professional and technician level is weighted toward the Information and Communication sector.
- Employment for R&D managers is strongest in Professional Services, reflecting the presence of scientific R&D activities in this sector.

Table 9: Distribution of employment in STEM job families by leading sectors

Job family	Top 3 industry sectors by employment		Job family	Top 3 industry sectors by employment
Managers (incl. production managers)	• Manufacturing (47%) • Wholesale & retail (12%) • Professional services (11%)		Quality professionals	• Manufacturing (20%) • Wholesale & retail (18%) • Professional services (14%)
Scientists	• Education (28%) • Professional services (22%) • Health & social work (19%)		STEM technicians	• Manufacturing (25%) • Professional services (17%) • Education (13%)
Engineering professionals	• Manufacturing (30%) • Construction (16%) • Professional services (15%)		IT technicians	• Information and communication (25%) • Professional services (21%) • Financial services (11%)
IT professionals	• Information and communication (36%) • Professional services (17%) • Financial services (9%)		Health and safety officers	• Professional services (31%) • Admin and support services (14%) • Public administration (8%)
Environmental professionals	• Information and communication (39%) • Public administration (15%) • Construction (8%)		IT engineers	• Information and communication (48%) • Professional services (21%) • Financial services (10%)
R&D managers	• Professional services (56%) • Manufacturing (11%) • Health & social work (8%)			

Source: Working Futures

As well as the absolute level of employment within a sector, it is also important to understand its density, i.e. expressed as a proportion of total employment. This is a useful measure as it demonstrates the importance of STEM skills to particular sectors, especially smaller ones which nonetheless may be critically important to the wider economy.

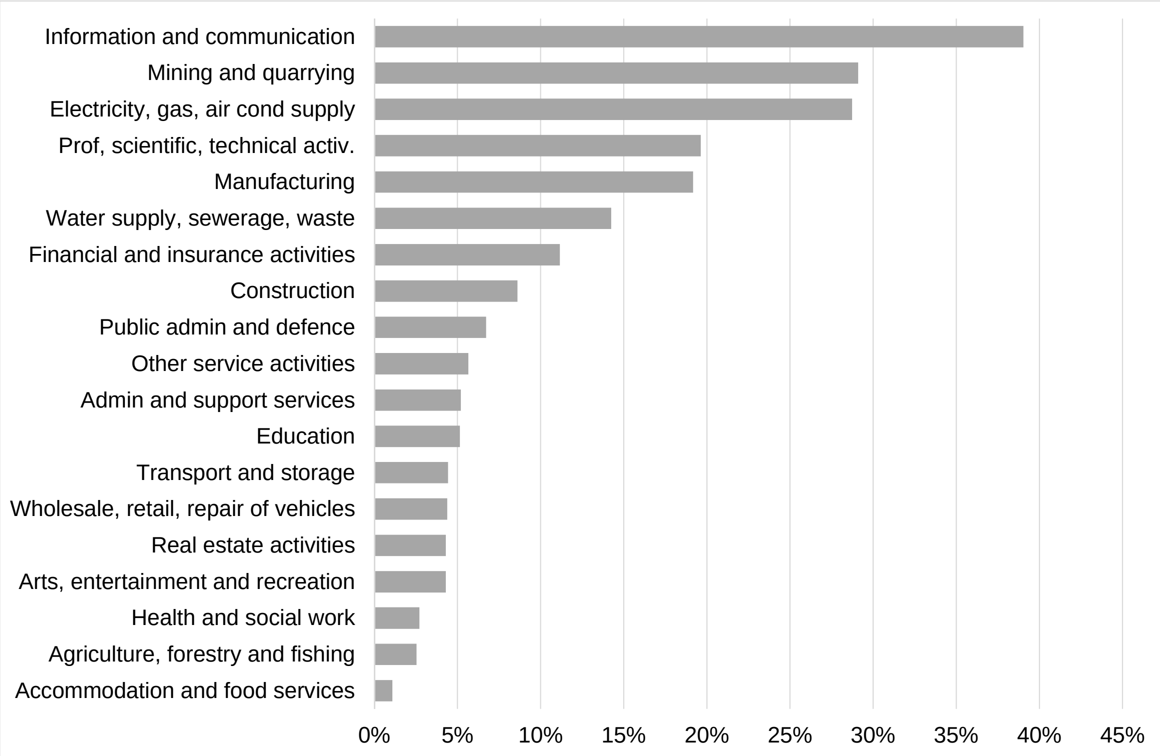
With regard to the “density” of high level STEM employment a few broad sectors demonstrate a high concentration of such jobs, while most are below the 10 per cent mark. By way of a benchmark, the density of high level STEM employment across the economy as a whole is nine per cent.

Information and communication has the highest density by some distance, with almost 40 per cent of total employment in high level STEM roles (see Figure 8). This reflects the fact that IT professionals and technicians form the core of the workforce in this sector.

Two sectors, Mining and Electricity have densities close to 30 per cent (although both have a relatively low level of employment in high level STEM jobs in absolute terms), whilst Professional services and Manufacturing both have densities close to 20 per cent.

Some sectors, such as Wholesale and retail, have high absolute levels of employment in high level STEM roles but a low density relative to their total employment.

Figure 8: UK employment in STEM occupations as a proportion of total employment by industry sector (SIC section)



Source: Working Futures

4.4.1 Prospects for high level STEM employment by sector

According to Working Futures, the overall level of employment in higher level STEM occupations is projected to grow by around 500,000 jobs, or 18 per cent, between 2012 and 2022.

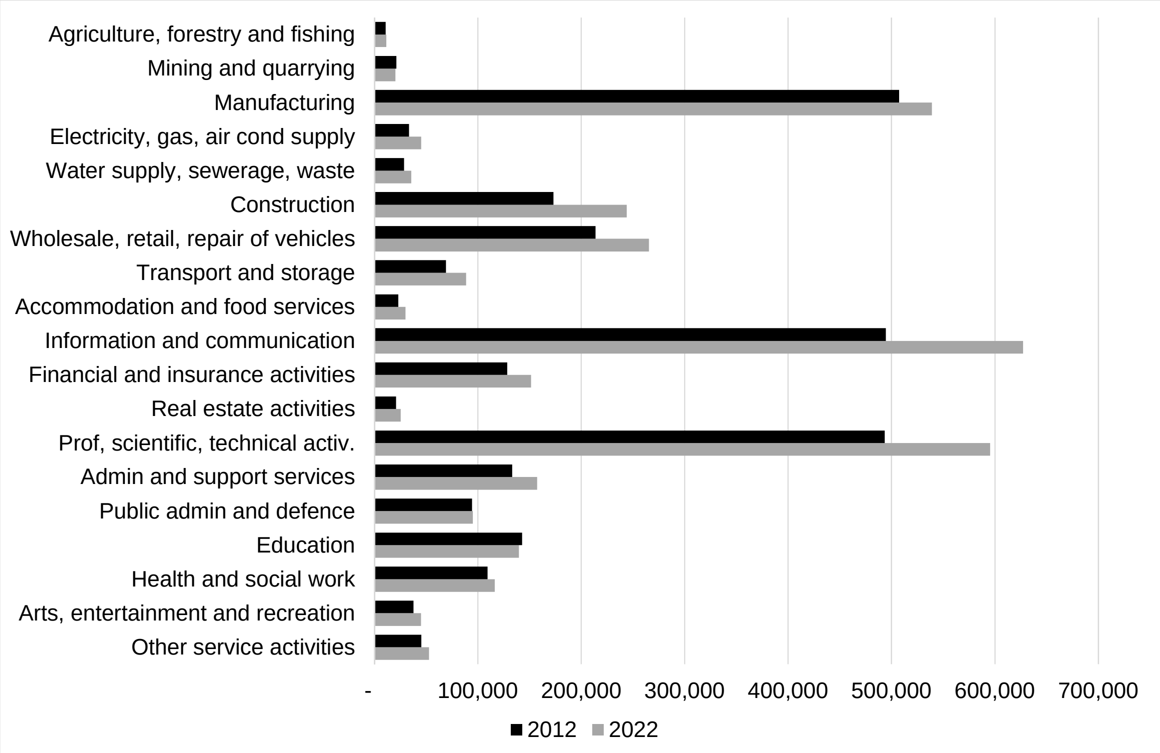
This growth rate is around three times the projected rate for UK employment as a whole and reflects the generally positive prospects for jobs at the associate professional and professional levels.

As Figure 9, demonstrates, employment in STEM occupations is projected to grow to some degree in almost all broad sectors. However, a key point to note is that growth is expected to be significantly greater in Professional services and Information and communication than in Manufacturing.

STEM employment in Information and communication is projected to grow by around a quarter (an extra 130,000 jobs) compared with a fifth (100,000 jobs) in Professional services.

Meanwhile projected growth in Manufacturing for the 10 year period is at single digit levels (around six per cent), adding around 30,000 jobs. This is relatively positive when one considers that a net decline is projected for overall employment in Manufacturing.

Figure 9: Projected net change in STEM employment by industry sector, 2012-2022 (SIC section)



Source: Working Futures

These variations reflect the continuing restructuring of the UK economy towards services and away from production activities. By 2022, both Professional services and Information and communication are projected to overtake Manufacturing in terms of high level STEM employment.

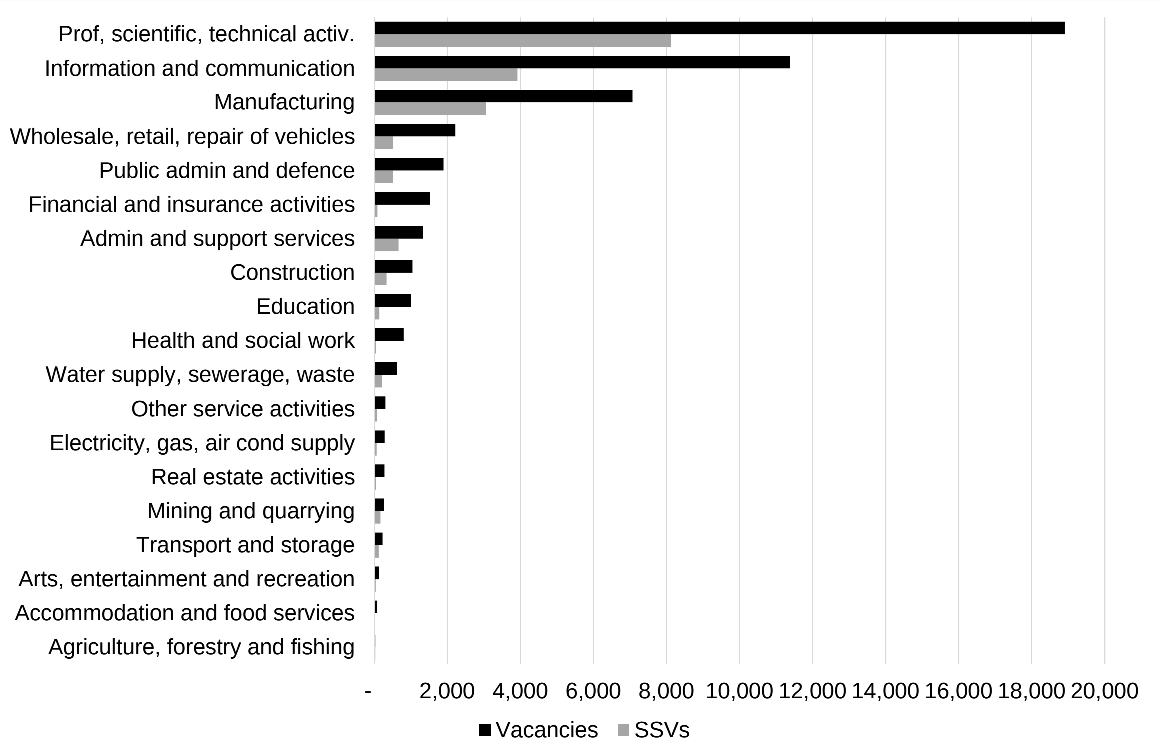
This pattern of change highlights the importance of thinking about high level STEM roles, such as Engineering professionals, in the context of outsourced delivery via organisations in the service sector.

4.4.2 Sectoral patterns of vacancies

Vacancies are another key indicator of labour market demand for high level STEM skills. We have already examined this indicator from the view of the occupations themselves. We now look at the picture by industry sector.

Figure 10, below, shows how vacancies and skill shortage vacancies arising from our defined STEM occupations are distributed by sector.

Figure 10: Distribution of vacancies and skill shortage vacancies for high level STEM occupations by SIC section



Source: UK Commission Employer Skills Survey, 2013

The figure indicates that the Professional services sector is by far the most significant source of both vacancies and skill shortage vacancies, accounting for 38 per cent and 45 per cent respectively. As might be expected from our previous analysis of the employment profile by sector, Information and communication and Manufacturing are the two other major sources of vacancies and skill shortage vacancies.

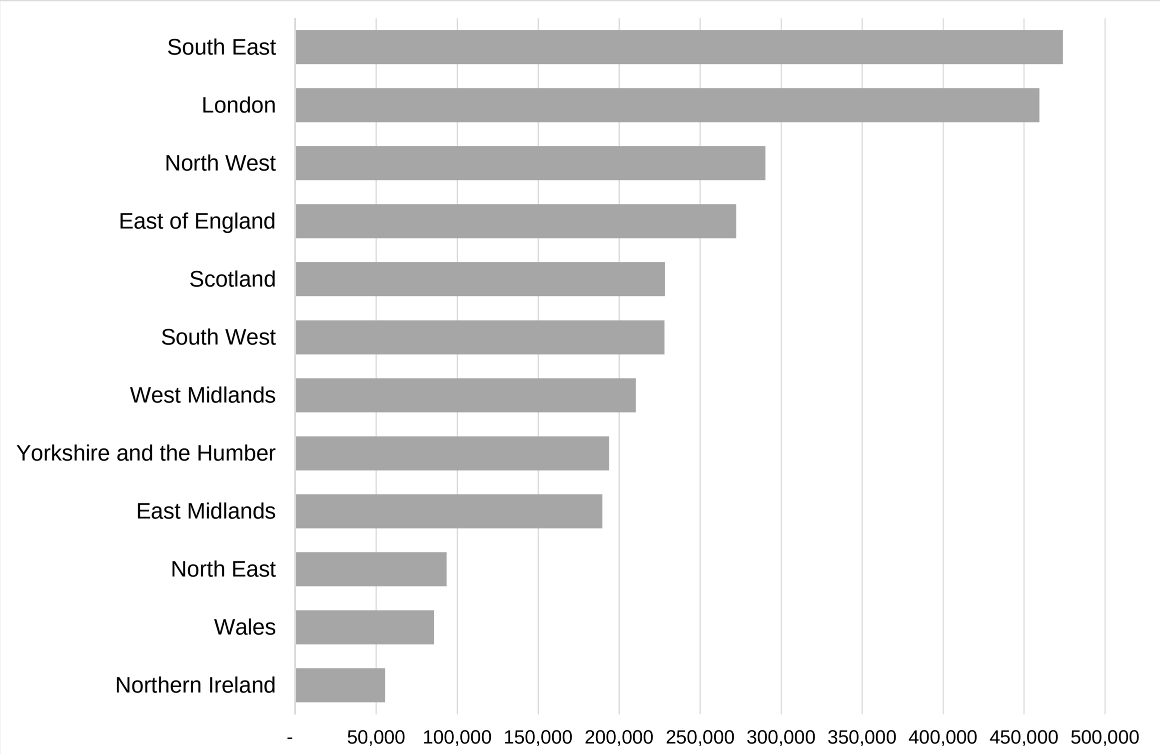
A key message from the analysis is that Professional services contributes a share of vacancies that is around twice its share of employment, implying that it is disproportionately important in terms of job creation. Skill shortages are also disproportionately concentrated in the sector relative to its share of employment. The converse of this is that there is a lower level of recruitment activity in respect of these occupations in Manufacturing.

The intensity or density of skill shortage vacancies (as a proportion of all vacancies) is however broadly similar across the leading sectors (although it is slightly lower in Information and communication). This suggests that where vacancies are advertised by Manufacturing establishments they are no more likely to become skill shortage vacancies than in Professional services.

4.5 Spatial patterns

We have examined the sectoral profile of high level STEM employment but how is such employment distributed spatially? This is an important consideration since employer action and public policy interventions must be grounded in a spatial context.

Figure 11: Distribution of employment in high level STEM occupations by devolved nation and English region, 2012



Source: Working Futures

Figure 11 shows how employment in high level STEM occupations is distributed across English regions and the devolved nations of the UK.

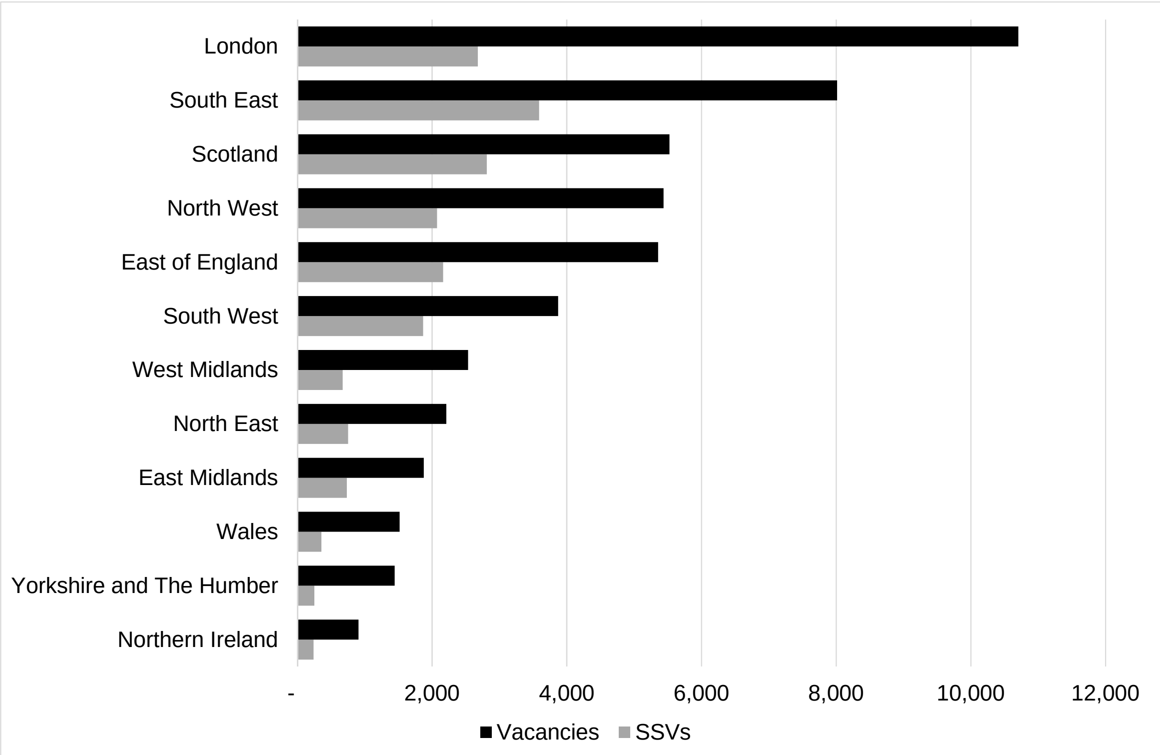
It indicates that employment in these roles is unevenly spread, as one would expect in view of the varying size of total employment across nations and regions. Three of the top four nations / regions are in the south eastern corner of England. The two regions of London and the South East together account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

However, it is important to note that this pattern is broadly in keeping with the distribution of employment as a whole, with only a slight “over-representation” of STEM jobs in Southern England.

Growth prospects for high level STEM employment do not vary greatly by region / nation. Projected growth is slightly above average in London and the South East (but also Northern Ireland and East Midlands) but below average in the North East and Wales.

Turning to the profile of vacancies by nation and region, the pattern is broadly similar to that seen for employment, although London and Scotland contribute slightly greater shares of vacancies than of employment. London and South East England hold dominant positions in terms of volume of vacancies reflecting their large concentrations of employment.

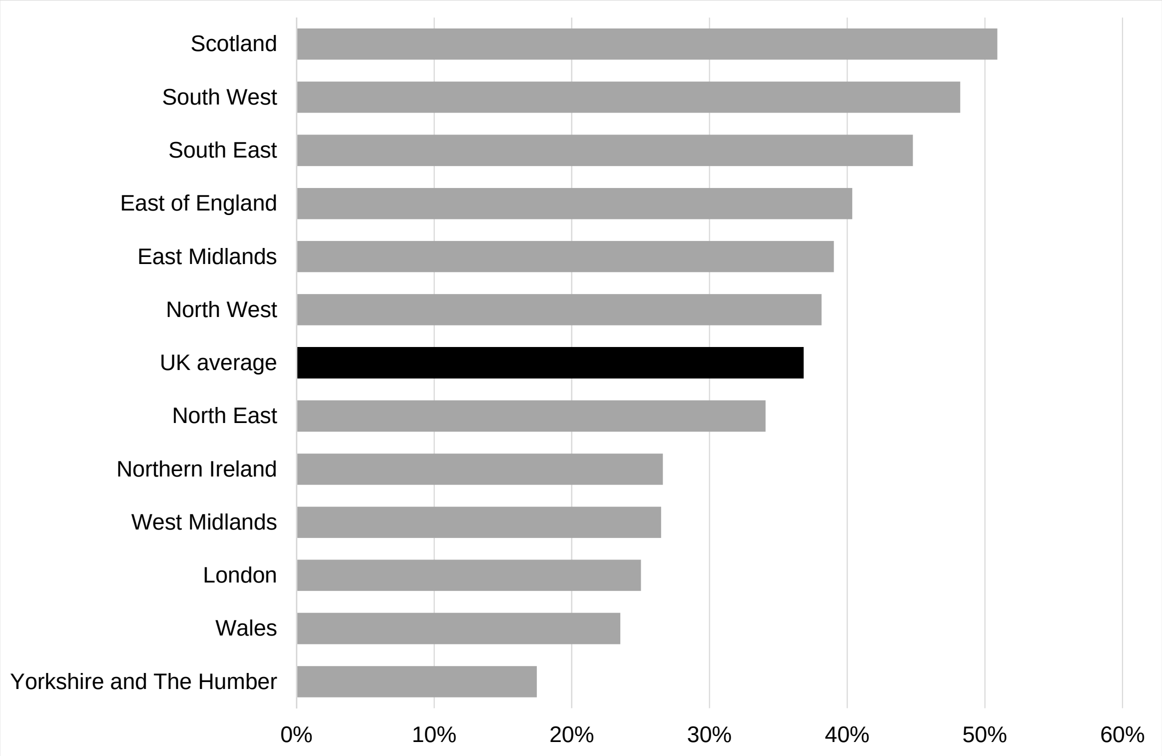
Figure 12: Distribution of vacancies and skill shortage vacancies for high level STEM occupations by devolved nation and English region, 2013



Source: UK Commission Employer Skills Survey, 2013

There is a degree of variation with regard to the density of skill shortages by nation and region. It seems that Scotland and South West England are particularly susceptible to shortages, with densities around 10 points higher than the UK average. South East England, the greatest source of shortages in absolute terms, is also slightly above average but London, the greatest source of vacancies, has a skill shortage density well below the UK average. This latter point shows that London has high levels of vacancies but suggests that it is relatively easy for employers in the region to fill them with skilled candidates. The higher density of shortages in the neighbouring region of the South East may be linked to the commuting patterns highlighted in section 2.9.

Figure 13: Density of skill shortage vacancies for high level STEM occupations by devolved nation and English region, 2013



Source: UK Commission Employer Skills Survey, 2013

4.6 Conclusions

Key conclusions from our analysis of the 11 high level STEM job families are as follows:

- The high level STEM occupations we have identified 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. A number of the families are relatively niche in size terms, including environment / conservation professionals, health and safety officers, R&D managers and IT engineers.
- High level STEM employment is widely distributed and is increasingly becoming service-sector based, with future job growth expected to be focused on areas like Professional services and Information and communication.
- Moreover, a disproportionate share of high level STEM vacancies (relative to employment) are found in the Professional services sector, suggesting that the sector plays an important role in job creation.

- This raises the question of how standards and frameworks should be contextualised to fit with these settings and how employer networks might best be organised to develop them.
- Employment in high level STEM occupations is weighted towards London and the South East but is important in all UK nations and English regions. Specific regional and local employment specialisms need to be assessed in order to define priorities at these levels.

5 Assessment of labour market need

Chapter Summary

- This chapter sets out the results of our assessment of the labour market need associated with high level STEM occupations.
- Our approach is founded on a labour market model that takes into account economic significance 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 / skills mismatch 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. The results are reviewed in detail using the framework of 11 job families to structure the 38 detailed occupations.
- Our analysis indicates that professional level skills relating to engineering and IT occupations are the leading priority, both scoring consistent highly against all indicators.
- 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.
- The level of labour market need associated with STEM Technician occupations 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. However, the prevalence of skill shortages is comparable to the professional groups.
- 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 and the need for effective progression routes.

5.1 Introduction

The chief objective of this review is to develop an understanding of the level of labour market need associated with high level STEM occupations as a basis for providing guidance on priorities for the development of higher apprenticeships.

But what do we mean by labour market need in the context of this analysis? We argue that high level occupations with the greatest need are those that combine current and future economic significance with evidence of market failure. The rationale for this is straightforward. By focusing on the most significant occupations we are directing attention at meeting the requirements of those areas that are important to maximising the potential return to society as well as to individual employers, sectors and individual workers, in the form of increased productivity, pay etc.

At the same time by concentrating on occupations affected by market failure in the form of skills mismatch we ensure that resources are targeted appropriately, on areas where the labour / learning market is operating sub-optimally. This is particularly important in those instances in which the public purse is co-investing alongside employers.

5.2 The indicators

Our starting point for formulating and selecting an appropriate basket of indicators is a set of simple principles, as follows:

- The indicators should reflect the underlying rationale around economic significance and market failure.
- Robust data should be available for the indicator.
- Items of interest should be susceptible to objective measurement rather than relying on value judgments.
- The overall “basket” of indicators should be coherent but as small as possible to minimise complexity and aid transparency.

In order to operationalise our basic rationale, whilst taking into account the above principles we selected indicators in the following areas:

- Economic significance / contribution, in the form of average pay by occupation
- Future prospects, in terms of projected employment growth and the likely level of future opportunities
- Market failure / skills mismatch – to what extent can employers secure the skills they need?

Further details of the indicators, together with their sources and rationale are provided in Table 10, below.

Table 10: Assessing labour market need: indicators

Key question	The indicator – what is it?	Why is it important?	How is it estimated?
Which occupations are the best paid?	*gross median pay for full-time jobs 2013.* This is the average wage earned by employees working in the occupation	Pay is a key indicator of a job's economic significance, reflecting its contribution to productivity as well as individual reward.	The Annual Survey of Hours and Earnings is based on a one per cent sample of employee jobs taken from HM Revenue and Customs PAYE records
Is the number of jobs in the occupation expected to grow?	*Net change in employment 2012 – 2022* This is the projected net change in the number of jobs in an occupation over the 10 year period. The absolute volume of growth / decline, in terms of the number of jobs, is used rather than the percentage rate.	An occupation with significant job growth is likely to offer strong employment prospects in the future as well as being a major focus for employer demand for apprentices as well as other workers. All else equal we should target occupations with positive growth prospects.	The *Working Futures* labour market model projects future occupational employment levels taking into account past trends
How many job opportunities are there expected to be in the occupation?	*Projected job openings 2012-2022* This is the number of job openings that we expect to see in an occupation, taking into account both net growth and replacement demands. The absolute volume of job openings is used rather than a proportion / percentage rate.	An occupation with a high number of job openings has strong "hiring demand" i.e. employers will need to recruit people to fill vacancies. Some occupations are expected to see net decline in the future but still have a strong need to replace workers as they leave the labour force due to retirement etc.	The *Working Futures* model projects replacement demands using historic data on the number of people who leave the labour force each year due to retirement, maternity leave etc. This is combined with data on net employment change
Are appropriately skilled people in short supply in this occupation?	*Skill shortages vacancies as % of total vacancies, 2013* This is the proportion of vacancies in an occupation that employers say are hard to fill because of a lack of skilled candidates	Occupations with a high prevalence of shortages are those in which employers cannot recruit the skilled and experienced people they need. This is a key indicator of business need and market failure.	The UK Commission's Employer Skills Survey asks about vacancies that are hard to fill due to a lack of skills. This survey is based on interviews with 90,000 business establishments

5.3 The modelling approach

Having selected our indicators we then developed the analytical process. First of all, to enable an assessment of variation between jobs across the different indicators we calculated a composite score for each occupation.

To create a single composite score it was firstly necessary to convert data into a ‘common currency’ so that they could be added together on a consistent basis. This standardisation is achieved by converting the scores for individual variables into z-scores which measure the difference between a data point and its respective average, measured in terms of standard deviations.

Z-scores have been capped at three standard deviations above or below the average to avoid any distortions that might otherwise be caused by extreme results. This is a prudent approach and reduces the risk of an occupation achieving an extremely high or low ranking based on a single data point. This is particularly pertinent in view of the fact that job openings and net job growth are expressed in absolute terms and some larger occupations register values for each of these indicators that are several times the size of other occupations. Similarly, a number of occupations attract levels of pay that are well in excess other occupations. The use of a cap within each indicator seeks to ensure that the overall composite score is based on a balanced picture across the range of indicators.

5.4 Weighting

This kind of modelling approach offers the option to influence the overall composite score by applying weights to each of the indicators to reflect their perceived importance to the overall outcome of the analytical exercise.

In this instance we have not applied weights to the four indicators. The results presented in this report reflect an equal weighting across the indicators. This decision has been made on grounds of transparency and simplicity.

However, this does not preclude the adoption of a different approach in future and it is acknowledged that sensible arguments can be presented for alternative weighting approaches to the one adopted here. A decision as to the relative weight that should be assigned to indicators is essentially a judgment-based process and may be best undertaken in conjunction with stakeholders, since there is a need to reflect shared priorities in the allocation of weights.

5.5 Results of the assessment of labour market need

Table 11 shows the 38 high level STEM occupations, ranked according to their overall score from the modelling exercise. Data tables setting out the results in more detail can be found in appendix C.

Looking at the results at a headline level, we note the following key points:

- Professional occupations dominate the upper reaches of the ranking, accounting for four out of the top five unit groups and 17 out of the top 20 occupations. This is probably to be expected in view of the fact that they are generally fast growing and well-paid.

- Drilling down in more detail IT professional occupations are particularly highly placed in the ranking. The Software developers / programmers occupation is ranked at number one and IT professional occupations account for five out of the top 10 occupations in the ranking.

- In the lower half of the ranking we find concentrations of technician and scientist occupations.

In the following section we provide a segmented analysis, which is designed to make the results for the 38 occupational unit groups more manageable. We have (in the main) used 3-digit SOC minor groups as the basis for 11 job families.

Table 11: Assessing labour market need: ranking of occupations based on results from model (descending order)

Rank	Occupation	Job family
1	Programmers and software development professionals (2136)	IT professionals
2	Production managers and directors in manufacturing (1121)	Managers (inc. production managers)
3	IT specialist managers (2133)	IT professionals
4	Information technology and telecommunications professionals n.e.c. (2139)	IT professionals
5	Engineering professionals n.e.c. (2129)	Engineering professionals
6	Mechanical engineers (2122)	Engineering professionals
7	IT business analysts, architects and systems designers (2135)	IT professionals
8	Design and development engineers (2126)	Engineering professionals
9	Civil engineers (2121)	Engineering professionals
10	IT project and programme managers (2134)	IT professionals
11	Electrical engineers (2123)	Engineering professionals
12	Production and process engineers (2127)	Engineering professionals
13	Electronics engineers (2124)	Engineering professionals
14	Information technology and telecommunications directors (1136)	IT professionals
15	Quality assurance and regulatory professionals (2462)	Quality professionals
16	Web design and development professionals (2137)	IT professionals
17	Engineering technicians (3113)	Science, engineering, production, technicians
18	Biological scientists and biochemists (2112)	Scientists
19	Health and safety officers (3567)	Health and safety officers
20	Research and development managers (2150)	R&D managers
21	Quality control and planning engineers (2461)	Quality professionals
22	Electrical and electronics technicians (3112)	Science, engineering, production, technicians
23	Natural and social science professionals n.e.c. (2119)	Scientists
24	Waste disposal and environmental services managers (1255)	Managers (inc. production managers)
25	Building and civil engineering technicians (3114)	Science, engineering, production, technicians
26	Planning, process and production technicians (3116)	Science, engineering, production, technicians
27	Laboratory technicians (3111)	Science, engineering, production, technicians
28	Production managers and directors in mining and energy (1123)	Managers (inc. production managers)
29	Environment professionals (2142)	Environment / conservation professionals
30	Science, engineering and production technicians n.e.c. (3119)	Science, engineering, production, technicians
31	Environmental health professionals (2463)	Quality professionals
32	Quality assurance technicians (3115)	Science, engineering, production, technicians
33	Physical scientists (2113)	Scientists
34	IT operations technicians (3131)	IT Technicians
35	Chemical scientists (2111)	Scientists
36	IT user support technicians (3132)	IT Technicians
37	Conservation professionals (2141)	Environment / conservation professionals
38	IT engineers (5245)	IT engineers

Source: UKCES STEM model

5.6 Analysis of labour market need by job family

The following section reviews how individual occupational groups perform in terms of the ranking and individual indicators. There are 38 occupational unit groups (4-digit categories) within scope of this analysis, making an examination of each one a cumbersome process. The following approach therefore focuses on the next level up, using 3-digit SOC minor groups, of which there are 11, as the basis for the analysis. In instances where there is a distinctive pattern of performance at unit group level, this is highlighted in the commentary.

5.6.1 Managers

Table 12: Indicators of labour market need: model scores and rankings for managers

Rank	Occupation	Net change jobs	Job openings	Skill shortages	Median pay	Overall score
2	Production managers and directors in manufacturing (1121)	3.00	3.00	-0.91	0.51	1.40
24	Waste disposal and environmental services managers (1255)	-0.80	-0.74	-0.66	0.14	-0.52
28	Production managers and directors in mining and energy (1123)	-0.63	-0.72	-0.91	0.00	-0.57

Source: UKCES STEM model

Three corporate management occupations feature in the list[6]; however it should be noted that a fourth management occupation, IT and telecoms directors, is considered with IT professional occupations, below.

The most prominent of the occupations is manufacturing production managers, which has an overall ranking of second in the list. This is a large occupation (employment of 280,000) with substantial projected net growth and recruitment requirement, as well as high average pay. Prevalence of skill shortage vacancies is modest, however, suggesting that the labour market is fairly effective in meeting skills needs.

Production managers in mining / energy and Waste disposal managers have low rankings. Both are relatively niche occupations in size terms and this feeds through to the scale of projected job growth and recruitment needs.

[6] These occupational unit groups range across two minor groups but have been collapsed into one category for the purposes of this analysis in order to simplify the analytical process.

Not surprisingly employment in the two production managers occupations is heavily concentrated in their respective sectors of manufacturing and energy. However, there is also significant employment of manufacturing production managers in wholesale and retail (reflecting the need for companies in this sector to manage manufacturing supply chains that often extend beyond the UK) and also in professional services.

5.6.2 Scientists

Table 13: Indicators of labour market need: model scores and rankings for scientists

Rank	Occupation	Net change jobs	Job openings	Skill shortages	Median pay	Overall score
18	Biological scientists and biochemists (2112)	0.30	0.21	-1.19	-0.19	-0.22
23	Natural and social science professionals n.e.c. (2119)	-0.21	-0.31	-1.19	-0.19	-0.48
33	Physical scientists (2113)	-0.55	-0.66	-1.19	0.00	-0.60
35	Chemical scientists (2111)	-0.45	-0.56	-1.19	-0.38	-0.65

Source: UKCES STEM model

Four scientific occupations feature in the list and within this job family.

Of these, only biologists feature in the top 20. This is due to a combination of factors. Aside from biologists, scientist occupations are modest in size (i.e. employ fewer than 50,000 people each) meaning limited job growth and recruitment needs in absolute terms.

Average pay and skill shortage vacancies are both moderate compared with other high level STEM occupations.

The higher ranking of biologists is mainly due to the relative scale of employment in the occupation, reflected in growth and recruitment prospects.

The pattern of sectoral distribution of employment in these occupations is complex. Health and social work is the leading sector for biologists; for physical scientists it is professional services (which includes scientific R&D activities); for chemical scientists it is manufacturing; whilst for the residual "n.e.c." scientific category, education is a key sector (this final category includes jobs like research assistants and research fellows working in universities).

5.6.3 Engineering professionals

Table 14: Indicators of labour market need: model scores and rankings for engineering professionals

Rank	Occupation	Net change jobs	Job openings	Skill shortages	Median pay	Overall score
5	Engineering professionals n.e.c. (2129)	0.49	0.40	1.60	0.33	0.71
6	Mechanical engineers (2122)	0.41	0.32	1.60	0.50	0.71
8	Design and development engineers (2126)	0.15	0.05	1.60	0.22	0.51
9	Civil engineers (2121)	0.23	0.13	1.60	0.01	0.49
11	Electrical engineers (2123)	-0.25	-0.35	1.60	0.74	0.43
12	Production and process engineers (2127)	-0.17	-0.27	1.60	0.07	0.31
13	Electronics engineers (2124)	-0.35	-0.45	1.60	0.20	0.25

Source: UKCES STEM model

Seven engineering professional occupations feature in the job family.

All of these occupations achieve a high ranking within the model, with four featuring in the top 10 and all seven making the top 20.

This is partly due to the fact that engineering professionals display the highest prevalence of skill shortages of any SOC minor group contained in the list.

Mechanical engineers and Engineering professionals n.e.c.[7] have the job greatest growth prospects and recruitment requirement of the seven occupations but most of these occupations are expected to generate a substantial level of future opportunities.

Electrical engineers and mechanical engineers have higher average pay than the other engineering professional occupations.

With regard to the sectoral distribution of jobs, a number of occupations have manufacturing as their leading sector: mechanical engineers, design / development engineers and production and process engineers. Civil engineers, meanwhile are concentrated in the construction sector.

[7] This unit group includes miscellaneous professional engineering occupations, including specialist roles in sectors such as nuclear, packaging and agriculture.

5.6.4 IT professionals

Table 15: Indicators of labour market need: model scores and rankings for IT professionals

Rank	Occupation	Net change jobs	Job openings	Skill shortages	Median pay	Overall score
1	Programmers and software development professionals (2136)	2.94	2.90	0.42	0.28	1.63
3	IT specialist managers (2133)	2.02	1.95	0.42	0.83	1.30
4	Information technology and telecommunications professionals n.e.c. (2139)	1.75	1.69	0.42	0.11	0.99
7	IT business analysts, architects and systems designers (2135)	0.67	0.58	0.42	0.50	0.54
10	IT project and programme managers (2134)	0.09	-0.01	0.42	1.34	0.46
14	Information technology and telecommunications directors (1136)	0.02	-0.03	-1.31	2.16	0.21
16	Web design and development professionals (2137)	0.07	-0.03	0.42	-0.75	-0.07

Six IT professional occupations and one IT management occupation feature in the ranking. They have been incorporated into one job family to reflect their shared focus on information technology.

All of these occupations achieve a high ranking within the model, with Programmers / developers ranked at number one and all occupations featuring in the top 20.

Some of the occupations are very large (e.g. employment of 277,000 for programmers) and combined with a high projected growth rate, substantial job growth and recruitment requirements are expected.

IT professional occupations also experience a high rate of skill shortage, although this is much less pronounced for IT directors.

Not surprisingly, average pay is high for IT directors but is also relatively high for IT project managers and IT specialist managers.

5.6.5 Research and development managers

Table 16: Indicators of labour market need: model scores and rankings for research and development managers

Rank	Occupation	Net change jobs	Job openings	Skill shortages	Median pay	Overall score
20	Research and development managers (2150)	-0.32	-0.43	-1.32	0.85	-0.30

This job family consists of a single occupation.

The majority of R&D managers are employed in the Professional services sector, which includes R&D activities. It should be noted, however, that the occupation includes jobs like market research manager as well as roles in scientific R&D.

The Research and development managers occupation has a middling position in the ranking. As an occupation with a small to medium level of employment, future growth and recruitment are likely to be moderate. Although median pay is relatively high there is a low reported prevalence of skill shortages.

5.6.6 Quality professionals

Table 17: Indicators of labour market need: model scores and rankings for quality professionals

Rank	Occupation	Net change jobs	Job openings	Skill shortages	Median pay	Overall score
15	Quality assurance and regulatory professionals (2462)	0.13	0.28	-0.32	0.09	0.05
21	Quality control and planning engineers (2461)	-0.51	-0.53	-0.32	-0.22	-0.40
31	Environmental health professionals (2463)	-0.74	-0.81	-0.32	-0.45	-0.58

This job family comprises three occupations.

One occupation, QA professionals, features in the top 20. This is a medium-sized occupation which is expected to see significant employment growth and recruitment needs. The median rate of pay is also higher than the other occupations in this job family.

The prevalence of skill shortages for occupations in this minor group is close to the average for high level STEM occupations.

5.6.7 Science, engineering, production, technicians

Table 18: Indicators of labour market need: model scores and rankings for Science, engineering, production, technicians

Rank	Occupation	Net change jobs	Job openings	Skill shortages	Median pay	Overall score
17	Engineering technicians (3113)	-0.39	-0.10	0.28	-0.47	-0.17
22	Electrical and electronics technicians (3112)	-0.75	-0.73	0.28	-0.62	-0.46
25	Building and civil engineering technicians (3114)	-0.81	-0.85	0.28	-0.79	-0.55
26	Planning, process and production technicians (3116)	-0.75	-0.74	0.28	-0.99	-0.55
27	Laboratory technicians (3111)	-0.45	-0.20	0.28	-1.88	-0.56

Rank	Occupation	Net change jobs	Job openings	Skill shortages	Median pay	Overall score
30	Science, engineering and production technicians n.e.c. (3119)	-0.70	-0.65	0.28	-1.22	-0.57
32	Quality assurance technicians (3115)	-0.78	-0.78	0.28	-1.11	-0.60

Seven STEM technician occupations feature in the ranking and within this job family.

Employment in this job family is most strongly concentrated in manufacturing, followed by professional services. A significant proportion of laboratory technicians work in the education sector.

Only one occupation, Engineering technicians, features in the top 20, with the remainder in the bottom half of the ranking.

Relatively low levels of pay contribute to this pattern of performance. This is to be expected since the ranking features a large number of professional occupations; although other contributing factors are the size of the occupations (most have employment below 50,000) and a relatively slow projected rate of job growth.

On the other hand these occupations are characterised by a high projected rate of replacement demands and a prevalence of skill shortages that is well above average.

Engineering technicians are differentiated from the other technician occupations by the scale of future employment growth and recruitment needs, as well as a slightly higher rate of pay.

5.6.8 Environmental professionals

Table 19: Indicators of labour market need: model scores and rankings for Environmental professionals

Rank	Occupation	Net change jobs	Job openings	Skill shortages	Median pay	Overall score
29	Environment professionals (2142)	-0.35	-0.45	-0.94	-0.54	-0.57
37	Conservation professionals (2141)	-0.69	-0.80	-0.94	-0.66	-0.77

Two occupations feature in this job family. Typically job titles contained in the environment professionals category include environmental engineer and environmental scientist. For conservation professionals they include conservation manager and ecologist.

Both occupations placed in the bottom half of the ranking.

This reflects their relatively small size (particularly conservation professionals) and hence limited contribution (in absolute terms) to job growth and job openings.

The prevalence of skill shortages is slightly below average.

The leading employment sector for this occupational group is Professional services, followed by Public administration.

5.6.9 IT Technicians

Table 20: Indicators of labour market need: model scores and rankings for IT Technicians

Rank	Occupation	Net change jobs	Job openings	Skill shortages	Median pay	Overall score
34	IT operations technicians (3131)	-0.23	0.18	-1.43	-0.97	-0.61
36	IT user support technicians (3132)	-0.40	-0.11	-1.43	-0.98	-0.73

Two IT technician occupations feature in the ranking of high level STEM occupations.

IT operations technicians are responsible for running IT systems, whilst user support technicians provide technical support and advice to end-users.

Both unit groups are positioned towards the bottom of the ranking.

Although both occupations are substantial in size and expected to be a focus for significant recruitment activity in the future, their rankings are pushed down by relatively low pay levels. This is a similar situation to STEM technicians.

In addition, however, the prevalence of skill shortages for this minor group is the lowest of any of the 38 STEM occupations under consideration. This contrasts with the shortage situation for IT occupations at the professional level and seems to suggest that the operation of the labour market is responding effectively to employer needs.

5.6.10 Health and safety officers

Table 21: Indicators of labour market need: model scores and rankings for Health and safety officers

Rank	Occupation	Net change jobs	Job openings	Skill shortages	Median pay	Overall score
19	Health and safety officers (3567)	-0.32	-0.27	0.12	-0.44	-0.23

This job family consists of a single occupation.

Health and safety officers co-ordinate health and safety measures within the workplace. The biggest employment sector for this occupation is professional services.

This occupation ranks within the top 20 partly by virtue of an above average prevalence of skill shortages.

Future job growth and recruitment requirement are fairly modest in absolute terms, whilst pay is towards the middle to lower end of the range.

5.6.11 IT engineers

Table 22: Indicators of labour market need: model scores and rankings for IT engineers

Rank	Occupation	Net change jobs	Job openings	Skill shortages	Median pay	Overall score
38	IT engineers (5245)	-1.11	-0.77	-0.22	-1.13	-0.81

IT engineers is the only occupation under consideration which is drawn from the Skilled trades major group. Workers in this role are not professional engineers, rather they install, repair and maintain IT equipment.

This is the lowest ranking of the 38 unit groups.

It is the only occupation that is forecast to see net decline in employment, contributing to a limited recruitment requirement.

The level of pay in the occupation is relatively low, whilst SSVs are around the average for high level STEM occupations.

5.7 Conclusions from the assessment of labour market need

A number of broad patterns emerge from this assessment of labour market need associated with STEM occupations.

As previously noted, professional occupations dominate the higher places in the ranking of STEM occupations. This is not surprising since these are the occupations requiring the highest level of skill and are therefore more likely to attract a relatively high rate of pay. In addition to this professional occupations in general are projected to see strong rates of net job growth over the next decade. Since some professional occupations are relatively large in employment terms, strong growth rates combined with replacement demands lead to large recruitment needs in absolute terms.

For occupations falling within the engineering professional and IT professional families this is further supplemented by a high prevalence of skill shortages. This explains why occupations from these groups dominate the ranking, accounting for all but one of the top 10 occupations.

Manufacturing production managers is the only occupational category to feature in the top 10 aside from engineering professional and IT professional occupations. This is a large occupation, with employment of more than a quarter of a million. Along with an above average projected growth rate this scale contributes to a substantial recruitment requirement. On the other hand the prevalence of skill shortages in this occupation is moderate. Overall, though, there is sufficient evidence to indicate that this occupation is a priority in terms of labour market need.

The position of scientists in the results of our analysis of labour market need is perhaps surprising in view of the importance of scientific knowledge to the process of innovation. Nonetheless, with the notable exception of biological scientists, scientist occupations have a relatively low position in the ranking. This is partly a function of the small scale in employment terms of each of the occupations, which feeds through to projected net job growth and recruitment needs. However, scale is only part of the picture. Moderate median pay levels and modest skill shortages also contribute to this position.

STEM technicians are clearly a group of key importance from the point of view of higher apprenticeships. A significant proportion of higher apprenticeship provision is targeted at them, reflecting the one of the main objectives of the programme which is to promote the development of progression pathways from intermediate skill levels to higher levels. As we have seen from our review of the evidence, technicians are widely seen to make an important and distinctive contribution in the workplace. However, the results of our modelling indicate that evidence of labour market need is less strong for technicians than for STEM roles at the professional level. The conclusion that could be drawn from this is that STEM skills at level 6 (i.e. degree level) and above are the foremost priority. However, as we argue below there is need for a balanced approach.

Two quality assurance / control occupations are ranked midway according to the results of the model. Quality assurance and regulatory professionals (ranked 15th) shows significant evidence of labour market need.

Although IT professional roles consistently perform strongly against our indicators of labour market need, this is not the case for IT technicians. In particular, there is little evidence of market failure in respect of occupations in this group. This suggest that this is an area of lesser priority, but as we note below, these occupations also need to be viewed as entry routes into the higher level occupations that do face persistent shortages.

5.8 Putting the conclusions into context

When interpreting these results for high level STEM occupations it is important to place them in the context of the wider labour market. Almost all of the 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. Conversely, STEM occupations often face much more intense skill shortages than other parts of the labour market. It is important not to lose sight of the fact that high level STEM occupations, taken together, demonstrate pronounced labour market need.

One of the key messages highlighted by this chapter is the evidence of strong need in the labour market for STEM professional occupations, relative to “lower level” occupations, notably associate professionals and technicians. When interpreting this finding it is important to consider the wider skills “ecosystem” in which the various occupations operate. In many instances a professional worker may not be able to operate effectively in the workplace in the absence of workers from other occupations. So, for example, a key part of the role of an engineering technician is to assist professional engineers in the design, development, operation, installation and maintenance of engineering systems. Technician level roles also act as an important potential entry route to professional level roles and employers and policymakers are keen to foster and widen this kind of progression pathway. This interdependence between different occupations means that a balanced approach to skills investment is required. Professional roles cannot be prioritised to an extent that is detrimental to other occupations.

From a review of the detailed results presented in section 5.6 it is clear that a common feature of these results is the importance of scale in determining the position of an occupation in the ranking. Although scale of employment is not an indicator in itself within the model it has a major influence on scores generated under the net job growth and job openings indicators. Occupations with a larger level of employment will have larger growth prospects (assuming that a positive growth rate is projected) and a larger recruitment requirement. It could be argued that this approach would systematically disadvantage smaller, niche occupation with strong growth rates, which may also face pronounced skills shortages. There is no strong evidence from the data that any of the smaller occupations face this scenario, although the available data precludes our ability to project occupational employment prospects at the most granular level.

We have not incorporated an indicator relating to the lead-in time required to develop skills and competencies relevant to an occupation, due to an lack of hard data. In theory, occupations with a longer lead-in time should be assigned a higher priority to reflect the extra time needed to bring vital skills to market and a more urgent requirement for action. Although we cannot quantify lead-in times with precision it seems certain that higher skilled professional occupations require a timescale for skills development that is longer and this lends additional weight to the argument that professional level skills are the leading priority.

There is also the question of the suitability of the various occupations to a work-based development route such as that offered by higher apprenticeships (considered in section 2.6). It could be argued that those occupations with a strong work-based tradition have a greater need for high quality apprenticeship standards and should be prioritised accordingly. Occupations with a tradition of academic entry may also be well catered for by this route. It could be similarly argued that occupations which offer a clear progression pathway from apprenticeships at the intermediate level should also be prioritised since widening progression routes is one of the key objectives of higher apprenticeships. Conversely, it could be argued that there is a need, whilst keeping within the bounds of practicality, to prioritise occupations without a tradition of work based development since it is important to spread the benefits of this approach more widely; this is particularly the case in view of the evidence of apparent weakness in some aspects of academic provision.

6 Availability of apprenticeship frameworks and standards

Chapter Summary

- As part of our review of the wider evidence we have conducted an analysis of the occupational coverage of existing Higher Apprenticeship frameworks and Trailblazer apprenticeship standards. 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. This analysis of the occupational coverage of apprenticeships is acknowledged to be indicative and susceptible to rapid change as the standards development programme proceeds.
- The analysis finds there is some coverage of management roles, with standards under development for production managers in the food sector under development whilst the existing framework in sustainable resource operations relates directly to waste disposal and environmental services managers.
- There is little coverage of scientist occupations, with one set of standards under development in relation to biological scientists. However, existing frameworks provide coverage for biological and chemical scientists. There does not appear to be any direct coverage of physical scientists in either standards or existing frameworks.
- 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.
- Most science, engineering and production technician occupations have some coverage in terms of standards that are available or under development, although some of these standards are positioned at level 3.
- Elsewhere, there are a number of occupations for which there do not appear to be any directly applicable standards, including the quality control and assurance occupations, research and development managers, conservation professionals and health and safety officers.

- A key general point to note is that many standards only offer narrow coverage of an occupation because they focus on the needs of a vertical industry sector. For example, the only sets of standards focusing on production managers specifically relate to the food and drink industry.

6.1 Introduction

As part of our review of the wider evidence and literature we have conducted an analysis of existing Higher Apprenticeship frameworks and also of trailblazer apprenticeship standards. We have mapped the available standards and frameworks to relevant high level occupations. By comparing this analysis with the results of our labour market modelling we can potentially identify gaps in the coverage of existing frameworks and standards.

It should very much be stressed that the standards development programme is at an early stage and therefore remains a work in progress. The following analysis is intended to provide helpful pointers for the ongoing development of standards for high level STEM occupations and should not be seen in any way as an evaluation of the standards programme.

Apprenticeship frameworks are used by colleges, employers and training providers to make sure that all apprenticeship programmes are delivered consistently and to national standards. They include the names of all qualifications and what each qualification is worth and also provide guidance on how to get onto an apprenticeship programme, the time it will take and career paths available after an apprenticeship. Frameworks tend to cover broad sectoral and functional areas, often with specific pathways for particular industries or occupational areas.

Apprenticeship standards set out the work that the apprentice will undertake and the skills required of them, by job role. Standards are developed by employer groups known as 'trailblazers'. Standards developed under the trailblazer process have been used by employers since September 2014. For the time being they co-exist alongside Higher Apprenticeship frameworks.

6.2 Approach

Information about existing apprenticeship frameworks and standards has been taken from published sources. Information about frameworks is available from the Apprenticeship Frameworks online website managed by the Federation for Industry Sector Skills and Standards, whilst details of standards, including standards ready for delivery and standards approved for development is accessible from the gov.uk website.

The frameworks and standards that we have examined do not typically use the SOC framework to define their occupational coverage. We have therefore used judgment to classify them to SOC using the job title information provided in the relevant documentation.

This is not an exact science. In particular, It should be noted that very limited information is publicly available for some trailblazer standards that are currently under development. Although we know the title of the job / occupation to be addressed by the standards, the proposed level of the standards is not always indicated.

The analysis of standards and frameworks dates from April 2015. This is a fast-moving area of development and the picture presented here is susceptible to rapid change as more standards enter the process or come on-stream.

In mapping the apprenticeship standards we have sought to allocate them to the occupation to which they are directly related. However, apprenticeship frameworks typically cover a range of job titles and their connection to individual occupational unit groups is less clear.

6.3 Mapping of standards to occupations

Table 23, below, provides a mapping of apprenticeship trailblazer standards to related high level STEM occupations.

Table 23: Mapping of higher apprenticeship standards to high level STEM occupations

Occupation	Standards ready to deliver	Standards under development
Production managers and directors in manufacturing (1121)		Production processing manager (food and drink) Technical manager (food and drink)
Production managers and directors in mining and energy (1123)		
Information technology and telecommunications directors (1136)		
Waste disposal and environmental services managers (1255)		
Chemical scientists (2111)		
Biological scientists and biochemists (2112)		Laboratory scientist (life and industrial sciences) (level 5)
Physical scientists (2113)		
Natural and social science professionals n.e.c. (2119)		
Civil engineers (2121)		Civil engineering site management (level 6)
Mechanical engineers (2122)	Manufacturing engineer (automotive) (level 6)	Aerospace engineer (level 6)
Electrical engineers (2123)	Electrical/Electronic Technical Support Engineer (automotive) (level 6)	
Electronics engineers (2124)	Electrical/Electronic Technical Support Engineer (automotive) (level 6)	Embedded Electronic Systems Design & Development Engineer (level 6) Outside Engineering Broadcast Engineer (level 7) Systems Engineering Masters Level (level 7)
Design and development engineers (2126)	Product Design & Development Engineer (automotive) (level 6)	
Production and process engineers (2127)	Control/technical support engineer (automotive) (level 6)	
Engineering professionals n.e.c. (2129)		Food science technologist (food and drink)
IT specialist managers (2133)		
IT project and programme managers (2134)		

Occupation	Standards ready to deliver	Standards under development
IT business analysts, architects and systems designers (2135)	Business analyst (6)*	Cyber intrusion analyst (digital) (4)
Programmers and software development professionals (2136)	Software developer (digital industries) (level 4) Software engineer (level 6)*	Software tester (digital) (4) Data analyst (digital) (4) Aerospace software developer (level 6)
Web design and development professionals (2137)		Digital media technology practitioner (level 4)
Information technology and telecoms professionals n.e.c. (2139)	Network engineer (level 4) Network engineer (6)* Cyber intrusion analyst (4) IT consultant (6)* Cyber security analyst (6)*	
Conservation professionals (2141)		
Environment professionals (2142)		
Research and development managers (2150)		
Quality control and planning engineers (2461)		
Quality assurance and regulatory professionals (2462)		
Environmental health professionals (2463)		
Laboratory technicians (3111)	Laboratory technician (life and industrial sciences) (level 3)	
Electrical and electronics technicians (3112)		Electronics systems technician
Engineering technicians (3113)		Rail engineering advanced technician / technician Refrigeration, air conditioning and heat pump engineering technician (level 3)
Planning, process and production technicians (3116)	Science Manufacturing Technician (life and industrial sciences) (3)	Water process technician (energy and utilities) (level 3)

Occupation	Standards ready to deliver	Standards under development
Science, engineering and production technicians n.e.c. (3119)		
IT operations technicians (3131)		Infrastructure technician (Digital industries) (4)
IT user support technicians (3132)		Unified communications trouble-shooter (Digital industries) (4)
Health and safety officers (3567)		
IT engineers (5245)		

Source: Gov.uk

*Specialisms within the Digital & Technology Solutions Professional degree apprenticeship

Apprenticeship standards are ready for delivery for a range of high level STEM occupations, with standards approved for development for a further selection of occupations. The general points from our review of standards are as follows:

- 10 standards are ready for delivery and 20 are under development (as of the end of April 2015). Within this four sets of standards are positioned at level 3 but have been included in this analysis since they apply directly to occupations that are within scope (e.g. standards for laboratory technicians).
- One or more sets of standards are ready for delivery or under development for 19 of the 38 occupational unit groups. This means that at this relatively early stage of the process around half of occupations do not have any standards.
- Most standards that are available or under development have a niche focus rather than covering the full scope of the occupation. Standards often view the occupation within a particular sectoral setting, reflecting the focus of employers (e.g. manufacturing engineer in the automotive sector). This assessment is based on the title of standard, however; the actual content of the standard may well have wider applicability across the occupation in question.
- Some occupations (such as Programmers / software developer and Electronics engineer) have multiple standards, which focus on specific job titles and functions within the occupation.

In addition to the apprenticeship standards that are ready for delivery or under development there are a range of higher apprenticeship frameworks that are live. These frameworks provide broader coverage of defined occupational areas. The relevant frameworks are profiled in Table 24, below.

Table 24: Mapping of higher apprenticeship frameworks

Framework	Occupational coverage	Comments
Higher Apprenticeship in Advanced Manufacturing Engineering - Level 4	Principal focus is on a variety of technician and senior technician occupations across a wide range of advanced manufacturing industries. There are multiple sector-based pathways.	Potentially leaves a gap for professional engineers and technologists who need to be qualified at level 5/6. Also a potential gap for production managers.
Higher Apprenticeship in Life Sciences & Chemical Science Professionals - Level 4 and 5	Covers technician and professional roles in chemical science, life science, food science and process development.	Covers professional scientific occupations relating to chemistry and life sciences but there appears to be no explicit coverage of physical sciences.
Higher Apprenticeship in Power Engineering – Level 4	Covers technician roles (but also some professional roles) that are specific to the power sector.	Framework comprises a single pathway and focus is on power sector.
Higher Apprenticeship for IT, Software, Web & Telecoms Professionals - Level 4	The stated purpose of the framework is to serve the needs of professionals across the IT / telecoms sector, including technical support, software development, telecoms engineering and database administration.	This framework provides broad coverage of IT professional roles. However, IT professional roles often require qualifications at levels 5 and 6. This is covered by the forthcoming degree apprenticeship for the Digital Industries.
Higher Apprenticeship in Information Security - Level 4 (England)	Focuses on the skills and knowledge required to become a professional in the field of information security. These jobs generally fall within the residual SOC unit group of Information Technology and Telecommunication Professionals n.e.c.	Research suggests that skills relating to information security are a key area of demand within the IT sphere.
Higher Apprenticeship in Interactive Design and Development - Level 4 (England)	This framework relates to job titles in the fields of software design, development and testing.	With regard to design / development roles, the framework is explicitly pitched at jobs that lie at a junior level.
Higher Apprenticeship in Digital Learning Design – Level 4 (England)	One of the roles covered by the framework is Digital Learning Designer, which is closely aligned to the occupation of software developer.	The development of interactive software and platforms to support learning is an important aspect of the Information Economy.

Framework	Occupational coverage	Comments
Higher Apprenticeship in Mineral Products Technology – Levels 4/5 (England)	Is broadly applicable to a wide range of STEM occupations at various levels within the Extractives, Cement, Concrete, Asphalt, Clay, and Deep Mining Industry, including technicians (e.g. engineering technicians, lab technicians), professionals (primarily engineering professional roles), managers (including production managers) and quality assurance managers.	The framework is broadly applicable to a wide range of high level STEM occupations within the specific context of the relevant industries.
Higher Apprenticeship in Engineering Environmental Technologies - Level 4 (England)	The job titles specified in the framework align to a range of occupations including Environment professional (e.g. environment engineer) and health and safety officer. The framework has pathways relating to the built environment, manufacturing engineering and building services engineering.	The framework provides coverage of environmental engineering roles across several sectoral areas.
Higher Apprenticeship in Sustainable Resource Operations and Management - Level 4 (England)	Framework covers job titles that mainly align with the Waste disposal and environmental services managers occupation.	Provides coverage of managements role in sustainable resource operations.

Source: Apprenticeship Frameworks Online

It is possible to examine the combined coverage at the occupational level provided by both trailblazer standards and existing higher apprenticeship frameworks. The following broad brush points seek to provide an interim assessment of this coverage for the high level STEM occupations.

- There is some coverage of management roles, with standards under development for production managers in the food sector under development. In addition, the existing framework in sustainable resource operations relates directly to waste disposal and environmental services managers.
- There is little coverage of scientist occupations, with one set of standards under development in relation to biological scientists. However, existing frameworks provide coverage for biological and chemical scientists. There does not appear to be any direct coverage of physical scientists in either standards and frameworks.
- 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 (particularly the framework in advanced manufacturing engineering) 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 also comprehensively covered at level 4 level by the existing framework for IT professionals.
- Most science, engineering and production technician occupations have some coverage in terms of standards that are available or under development. Some of these standards are positioned at level 3, however, and cannot be considered high level.
- Elsewhere, there are a number of occupations for which there do not appear to be any directly applicable standards, including the quality control and assurance occupations, research and development managers, conservation professionals and health and safety officers.

6.4 Conclusion

Our initial analysis of the emerging body of higher level apprenticeship standards, together with existing Higher Apprenticeship frameworks, indicates 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 engineering professional and 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.

The UK Commission's overall view is that apprenticeships need to be configured to provide coherent career pathways to support individual progression. This means that the main pathways in respect of STEM occupations need to be mapped and relevant standards put in place to support individual progression.

7 Conclusions and recommendations

Chapter Summary

- Our analysis confirms that high level STEM skills are of key importance to the performance of the UK economy in terms of the key dimensions of jobs, productivity, innovation and competitiveness.
- We believe that there is no overall undersupply of qualified individuals to meet the demand for high level STEM workers but that there are acute shortages in specific occupational areas. Investment by employers in training may currently not be sufficient to mitigate shortages and meet business need.
- 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 relative to occupations with labour market need which need to be considered as the standards development programme proceeds.
- Our main recommendation relates to the need to ensure that apprenticeships support coherent pathways to professional and management roles within the STEM sphere and that apprenticeship standards provide sufficiently extensive coverage of the range of jobs roles within each occupational area.
- There is also a need for further research to support the development of the agenda around high level STEM skills as detailed below.

7.1 Introduction

This chapter puts forward a series of overall conclusions relating to labour market priorities in the sphere of high level STEM occupations. These are based on our modelling work and our wider review of the evidence base pertaining to STEM skills.

Linked to these conclusions are a series of high level recommendations relating to actions by employers and government to ensure that there is suitable coverage of the occupations with regard to apprenticeships and other higher vocational provision, as employers seek to put in place solutions to meet the skill needs of their sectors and occupations.

7.2 Conclusions

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. There is some evidence to suggest that investment by employers in the development of their existing staff STEM may be low relative to comparable occupational areas and may not be sufficient to meet business need. This requires further exploration.

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 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 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.

The primary focus of 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 in order to provide effective progression routes to the professional occupations that we have identified as labour market priorities.

7.3 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.

7.4 Further research

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 analysis of progression pathways within the STEM occupational sphere. This intelligence could be used to ensure that career pathways are effectively supported by apprenticeships.
- 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?
- 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.

Appendix A: Longlist of STEM occupations

SOC10M	Description	STEM	Proportion of STEM graduates (%)	Index of STEM skills use
1115	Chief executives and senior officials	Not STEM	16.08	0.59
1116	Elected officers and representatives	Not STEM	12.93	0.48
1121	Production managers and directors in manufacturing	STEM	17.89	0.61
1122	Production managers and directors in construction	Not STEM	9.09	0.81
1123	Production managers and directors in mining and energy	STEM	20.11	0.67
1131	Financial managers and directors	Not STEM	9.63	0.83
1132	Marketing and sales directors	Not STEM	10.15	0.32
1133	Purchasing managers and directors	Not STEM	12.23	0.71
1134	Advertising and public relations directors	Not STEM	6.94	0.57
1135	Human resource managers and directors	Not STEM	9.52	0.39
1136	Information technology and telecommunications directors	STEM	29.19	0.70
1139	Functional managers and directors n.e.c.	Not STEM	14.04	0.44
1150	Financial institution managers and directors	Not STEM	6.48	0.78
1161	Managers and directors in transport and distribution	Not STEM	4.99	0.54
1162	Managers and directors in storage and warehousing	Not STEM	3.84	0.44
1171	Officers in armed forces	STEM	25.39	0.63
1172	Senior police officers	Not STEM	12.54	-0.15
1173	Senior officers in fire, ambulance, prison and related services	Not STEM	4.64	0.30
1181	Health services and public health managers and directors	STEM	27.11	0.37
1184	Social services managers and directors	Not STEM	9.23	0.56
1190	Managers and directors in retail and wholesale	Not STEM	5.34	0.10
1211	Managers and proprietors in agriculture and horticulture	Not STEM	9.30	0.34
1213	Managers and proprietors in forestry, fishing and related services	Not STEM	12.55	0.36
1221	Hotel and accommodation managers and proprietors	Not STEM	5.16	0.12
1223	Restaurant and catering establishment managers and proprietors	Not STEM	3.70	0.18
1224	Publicans and managers of licensed premises	Not STEM	2.41	0.11
1225	Leisure and sports managers	Not STEM	8.52	0.14
1226	Travel agency managers and proprietors	Not STEM	2.18	0.15
1241	Health care practice managers	Not STEM	7.43	0.72
1242	Residential, day and domiciliary care managers and proprietors	Not STEM	7.20	0.43
1251	Property, housing and estate managers	Not STEM	7.55	0.39
1252	Garage managers and proprietors	Not STEM	1.87	0.36
1253	Hairdressing and beauty salon managers and proprietors	Not STEM	0.92	-0.27
1254	Shopkeepers and proprietors: wholesale and retail	Not STEM	3.79	-0.11
1255	Waste disposal and environmental services managers	STEM	17.45	0.41
1259	Managers and proprietors in other services n.e.c.	Not STEM	8.28	0.70
2111	Chemical scientists	STEM	69.04	0.98
2112	Biological scientists and biochemists	STEM	69.19	0.80
2113	Physical scientists	STEM	70.21	0.79
2114	Social and humanities scientists	Not STEM	12.12	0.51
2119	Natural and social science professionals n.e.c.	STEM	56.32	0.95
2121	Civil engineers	STEM	49.59	0.90
2122	Mechanical engineers	STEM	33.23	0.73
2123	Electrical engineers	STEM	26.07	0.68
2124	Electronics engineers	STEM	31.45	0.82
2126	Design and development engineers	STEM	39.46	1.03
2127	Production and process engineers	STEM	33.95	0.68
2129	Engineering professionals n.e.c.	STEM	30.48	0.66
2133	IT specialist managers	STEM	26.78	0.57
2134	IT project and programme managers	STEM	25.25	0.71
2135	IT business analysts, architects and systems designers	STEM	35.52	1.01
2136	Programmers and software development professionals	STEM	44.49	0.87
2137	Web design and development professionals	STEM	23.66	0.73
2139	Information technology and telecommunications professionals n.e.c.	STEM	30.82	0.91
2141	Conservation professionals	STEM	50.29	0.62
2142	Environment professionals	STEM	53.70	0.48
2150	Research and development managers	STEM	41.28	0.70
2211	Medical practitioners	STEM	70.38	0.51
2212	Psychologists	STEM	86.50	0.67
2213	Pharmacists	STEM	77.99	0.87
2214	Ophthalmic opticians	STEM	80.12	-0.41
2215	Dental practitioners	STEM	76.27	0.23
2216	Veterinarians	STEM	71.02	0.43
2217	Medical radiographers	STEM	64.03	0.47
2218	Podiatrists	STEM	45.84	0.15
2219	Health professionals n.e.c.	STEM	38.96	-0.02
2221	Physiotherapists	STEM	70.24	0.12
2222	Occupational therapists	STEM	65.16	-0.07

SOC10M	Description	STEM	Proportion of STEM graduates (%)	Index of STEM skills use
2223	Speech and language therapists	STEM	60.77	-0.39
2229	Therapy professionals n.e.c.	STEM	53.05	0.12
2231	Nurses	STEM	28.64	0.34
2232	Midwives	STEM	46.91	0.17
2311	Higher education teaching professionals	STEM	31.42	0.81
2312	Further education teaching professionals	Not STEM	16.46	0.43
2314	Secondary education teaching professionals	STEM	22.12	0.34
2315	Primary and nursery education teaching professionals	Not STEM	5.79	0.47
2316	Special needs education teaching professionals	Not STEM	5.37	0.21
2317	Senior professionals of educational establishments	Not STEM	9.37	0.55
2318	Education advisers and school inspectors	Not STEM	13.09	0.50
2319	Teaching and other educational professionals n.e.c.	Not STEM	8.61	0.12
2412	Barristers and judges	Not STEM	2.08	0.52
2413	Solicitors	Not STEM	2.76	0.51
2419	Legal professionals n.e.c.	Not STEM	2.22	0.42
2421	Chartered and certified accountants	Not STEM	9.94	1.02
2423	Management consultants and business analysts	STEM	20.99	1.01
2424	Business and financial project management professionals	STEM	19.67	0.38
2425	Actuaries, economists and statisticians	STEM	46.61	0.78
2426	Business and related research professionals	STEM	22.36	1.15
2429	Business, research and administrative professionals n.e.c.	Not STEM	13.49	0.68
2431	Architects	Not STEM	2.20	1.00
2432	Town planning officers	Not STEM	6.59	0.29
2433	Quantity surveyors	Not STEM	8.16	0.65
2434	Chartered surveyors	Not STEM	14.71	1.02
2435	Chartered architectural technologists	Not STEM	7.24	0.68
2436	Construction project managers and related professionals	Not STEM	14.09	0.19
2442	Social workers	Not STEM	4.40	0.08
2443	Probation officers	Not STEM	12.13	0.11
2444	Clergy	Not STEM	6.89	0.18
2449	Welfare professionals n.e.c.	Not STEM	9.20	0.13
2451	Librarians	Not STEM	3.67	-0.48
2452	Archivists and curators	Not STEM	9.63	0.11
2461	Quality control and planning engineers	STEM	19.74	0.38
2462	Quality assurance and regulatory professionals	STEM	23.15	0.93
2463	Environmental health professionals	STEM	50.43	0.62
2471	Journalists, newspaper and periodical editors	Not STEM	10.91	0.14
2472	Public relations professionals	Not STEM	9.57	-0.32
2473	Advertising accounts managers and creative directors	Not STEM	6.00	0.11
3111	Laboratory technicians	STEM	30.00	0.44
3112	Electrical and electronics technicians	Not STEM	7.29	0.57
3113	Engineering technicians	Not STEM	10.81	0.47
3114	Building and civil engineering technicians	Not STEM	14.55	0.81
3115	Quality assurance technicians	STEM	17.51	0.26
3116	Planning, process and production technicians	Not STEM	5.99	0.71
3119	Science, engineering and production technicians n.e.c.	Not STEM	14.85	0.25
3121	Architectural and town planning technicians	Not STEM	4.81	0.38
3122	Draughtspersons	Not STEM	8.15	0.90
3131	IT operations technicians	STEM	19.22	0.38
3132	IT user support technicians	STEM	21.90	0.32
3213	Paramedics	Not STEM	14.19	0.54
3216	Dispensing opticians	Not STEM	14.38	-0.02
3217	Pharmaceutical technicians	Not STEM	9.48	0.03
3218	Medical and dental technicians	Not STEM	16.62	-0.53
3219	Health associate professionals n.e.c.	STEM	23.52	-0.29
3231	Youth and community workers	Not STEM	5.42	0.08
3233	Child and early years officers	Not STEM	5.04	-0.23
3234	Housing officers	Not STEM	5.71	-0.07
3235	Counsellors	STEM	21.55	0.09
3239	Welfare and housing associate professionals n.e.c.	Not STEM	7.71	-0.02
3311	NCOs and other ranks	Not STEM	2.18	-0.18
3312	Police officers (sergeant and below)	Not STEM	8.18	-0.04
3313	Fire service officers (watch manager and below)	Not STEM	3.71	-0.27
3314	Prison service officers (below principal officer)	Not STEM	3.49	-0.26
3315	Police community support officers	Not STEM	2.30	-0.08
3319	Protective service associate professionals n.e.c.	Not STEM	9.84	0.22
3411	Artists	Not STEM	2.79	-0.08
3412	Authors, writers and translators	Not STEM	10.02	0.55
3413	Actors, entertainers and presenters	Not STEM	2.45	-0.51
3414	Dancers and choreographers	Not STEM	0.88	0.05
3415	Musicians	Not STEM	3.25	-0.23
3416	Arts officers, producers and directors	Not STEM	5.00	0.12
3417	Photographers, audio-visual and broadcasting equipment operators	Not STEM	9.08	-0.34

SOC10M	Description	STEM	Proportion of STEM graduates (%)	Index of STEM skills use
3421	Graphic designers	Not STEM	3.63	0.17
3422	Product, clothing and related designers	Not STEM	4.98	0.38
3441	Sports players	Not STEM	5.64	-0.34
3442	Sports coaches, instructors and officials	Not STEM	12.33	-0.34
3443	Fitness instructors	Not STEM	10.63	-0.25
3511	Air traffic controllers	Not STEM	10.67	0.21
3512	Aircraft pilots and flight engineers	STEM	29.87	0.58
3513	Ship and hovercraft officers	Not STEM	5.79	0.21
3520	Legal associate professionals	Not STEM	4.69	0.43
3531	Estimators, valuers and assessors	Not STEM	8.91	0.68
3532	Brokers	Not STEM	8.38	0.57
3533	Insurance underwriters	Not STEM	5.90	0.45
3534	Finance and investment analysts and advisers	Not STEM	9.67	0.74
3535	Taxation experts	Not STEM	9.58	1.08
3536	Importers and exporters	Not STEM	6.97	0.69
3537	Financial and accounting technicians	Not STEM	5.88	1.11
3538	Financial accounts managers	Not STEM	7.72	0.60
3539	Business and related associate professionals n.e.c.	Not STEM	15.49	0.72
3541	Buyers and procurement officers	Not STEM	6.28	0.44
3542	Business sales executives	Not STEM	8.67	0.28
3543	Marketing associate professionals	Not STEM	7.44	0.42
3544	Estate agents and auctioneers	Not STEM	4.30	0.30
3545	Sales accounts and business development managers	Not STEM	10.66	0.52
3546	Conference and exhibition managers and organisers	Not STEM	3.83	0.21
3550	Conservation and environmental associate professionals	STEM	27.56	0.42
3561	Public services associate professionals	Not STEM	10.15	0.43
3562	Human resources and industrial relations officers	Not STEM	7.07	-0.13
3563	Vocational and industrial trainers and instructors	Not STEM	8.47	0.11
3564	Careers advisers and vocational guidance specialists	Not STEM	6.66	-0.52
3565	Inspectors of standards and regulations	Not STEM	14.78	0.42
3567	Health and safety officers	STEM	17.22	0.47
4112	National government administrative occupations	Not STEM	4.08	0.02
4113	Local government administrative occupations	Not STEM	4.24	0.10
4114	Officers of non-governmental organisations	Not STEM	8.21	-0.23
4121	Credit controllers	Not STEM	3.08	0.19
4122	Book-keepers, payroll managers and wages clerks	Not STEM	4.85	0.56
4123	Bank and post office clerks	Not STEM	2.97	-0.01
4124	Finance officers	Not STEM	4.84	0.43
4129	Financial administrative occupations n.e.c.	Not STEM	4.21	0.55
4131	Records clerks and assistants	Not STEM	4.37	-0.18
4132	Pensions and insurance clerks and assistants	Not STEM	4.98	0.20
4133	Stock control clerks and assistants	Not STEM	1.53	0.15
4134	Transport and distribution clerks and assistants	Not STEM	2.26	0.20
4135	Library clerks and assistants	Not STEM	3.09	-0.52
4138	Human resources administrative occupations	Not STEM	4.86	-0.02
4151	Sales administrators	Not STEM	1.46	0.31
4159	Other administrative occupations n.e.c.	Not STEM	3.50	-0.10
4161	Office managers	Not STEM	4.70	0.57
4162	Office supervisors	Not STEM	4.02	0.54
4211	Medical secretaries	Not STEM	2.70	-0.07
4212	Legal secretaries	Not STEM	2.09	-0.22
4213	School secretaries	Not STEM	3.11	-0.02
4214	Company secretaries	Not STEM	3.37	-0.06
4215	Personal assistants and other secretaries	Not STEM	1.52	-0.31
4216	Receptionists	Not STEM	1.85	-0.49
4217	Typists and related keyboard occupations	Not STEM	5.32	-0.10
5111	Farmers	Not STEM	3.62	0.15
5112	Horticultural trades	Not STEM	5.91	-0.09
5113	Gardeners and landscape gardeners	Not STEM	3.65	-1.10
5114	Groundsmen and greenkeepers	Not STEM	1.27	-0.39
5119	Agricultural and fishing trades n.e.c.	Not STEM	2.77	-0.14
5211	Smiths and forge workers	Not STEM	2.78	-0.17
5212	Moulders, core makers and die casters	Not STEM	0.00	-0.25
5213	Sheet metal workers	Not STEM	0.00	0.10
5214	Metal plate workers, and riveters	Not STEM	0.00	-1.02
5215	Welding trades	Not STEM	0.32	-0.23
5216	Pipe fitters	Not STEM	2.50	0.12
5221	Metal machining setters and setter-operators	Not STEM	0.73	0.17
5222	Tool makers, tool fitters and markers-out	Not STEM	0.00	0.06
5223	Metal working production and maintenance fitters	Not STEM	1.75	0.15
5224	Precision instrument makers and repairers	Not STEM	5.71	0.54
5231	Vehicle technicians, mechanics and electricians	Not STEM	1.02	0.05
5232	Vehicle body builders and repairers	Not STEM	0.37	-0.23

SOC10M	Description	STEM	Proportion of STEM graduates (%)	Index of STEM skills use
5234	Vehicle paint technicians	Not STEM	0.76	-0.55
5235	Aircraft maintenance and related trades	Not STEM	5.51	0.51
5236	Boat and ship builders and repairers	Not STEM	6.88	0.11
5241	Electricians and electrical fitters	Not STEM	2.78	0.24
5242	Telecommunications engineers	Not STEM	4.15	0.55
5244	TV, video and audio engineers	Not STEM	1.99	0.52
5245	IT engineers	STEM	18.53	0.40
5249	Electrical and electronic trades n.e.c.	Not STEM	7.82	0.37
5250	Skilled metal, electrical and electronic trades supervisors	Not STEM	1.87	0.16
5311	Steel erectors	Not STEM	0.00	0.40
5312	Bricklayers and masons	Not STEM	0.15	-0.22
5313	Roofers, roof tilers and slaters	Not STEM	0.18	-0.43
5314	Plumbers and heating and ventilating engineers	Not STEM	0.99	0.32
5315	Carpenters and joiners	Not STEM	0.31	-0.12
5316	Glaziers, window fabricators and fitters	Not STEM	0.84	-0.45
5319	Construction and building trades n.e.c.	Not STEM	1.95	-0.26
5321	Plasterers	Not STEM	0.00	-0.47
5322	Floorers and wall tilers	Not STEM	0.00	-0.63
5323	Painters and decorators	Not STEM	0.56	-0.73
5330	Construction and building trades supervisors	Not STEM	2.26	-0.35
5411	Weavers and knitters	STEM	24.24	-0.41
5412	Upholsterers	Not STEM	1.43	-0.11
5413	Footwear and leather working trades	Not STEM	0.53	-0.41
5414	Tailors and dressmakers	Not STEM	1.63	-1.14
5419	Textiles, garments and related trades n.e.c.	Not STEM	0.71	-0.41
5421	Pre-press technicians	Not STEM	6.01	-0.25
5422	Printers	Not STEM	0.89	0.08
5423	Print finishing and binding workers	Not STEM	1.33	-0.61
5431	Butchers	Not STEM	1.02	-0.53
5432	Bakers and flour confectioners	Not STEM	0.99	-1.23
5433	Fishmongers and poultry dressers	Not STEM	0.00	-0.63
5434	Chefs	Not STEM	1.08	-0.75
5435	Cooks	Not STEM	0.33	-0.45
5436	Catering and bar managers	Not STEM	0.64	0.09
5441	Glass and ceramics makers, decorators and finishers	Not STEM	3.87	-1.21
5442	Furniture makers and other craft woodworkers	Not STEM	2.27	-0.49
5443	Florists	Not STEM	1.34	-0.25
5449	Other skilled trades n.e.c.	Not STEM	2.56	-0.61
6121	Nursery nurses and assistants	Not STEM	1.59	-0.43
6122	Childminders and related occupations	Not STEM	2.89	-0.77
6123	Playworkers	Not STEM	1.24	-0.66
6125	Teaching assistants	Not STEM	3.38	-0.20
6126	Educational support assistants	Not STEM	5.18	-0.17
6131	Veterinary nurses	Not STEM	10.07	0.08
6132	Pest control officers	Not STEM	3.73	-0.23
6139	Animal care services occupations n.e.c.	Not STEM	4.65	-0.34
6141	Nursing auxiliaries and assistants	Not STEM	4.90	-0.56
6142	Ambulance staff (excluding paramedics)	Not STEM	4.03	-0.74
6143	Dental nurses	Not STEM	1.45	-0.34
6144	Houseparents and residential wardens	Not STEM	1.13	-0.23
6145	Care workers and home carers	Not STEM	1.79	-0.64
6146	Senior care workers	Not STEM	2.59	-0.43
6147	Care escorts	Not STEM	0.00	-0.59
6148	Undertakers, mortuary and crematorium assistants	Not STEM	0.83	-0.59
6211	Sports and leisure assistants	Not STEM	3.24	-0.47
6212	Travel agents	Not STEM	1.58	0.43
6214	Air travel assistants	Not STEM	1.84	-0.53
6215	Rail travel assistants	Not STEM	2.85	-0.21
6219	Leisure and travel service occupations n.e.c.	Not STEM	3.96	-0.68
6221	Hairdressers and barbers	Not STEM	0.16	-0.76
6222	Beauticians and related occupations	Not STEM	1.13	-0.56
6231	Housekeepers and related occupations	Not STEM	0.92	-0.77
6232	Caretakers	Not STEM	0.92	-0.54
6240	Cleaning and housekeeping managers and supervisors	Not STEM	0.84	-1.94
7111	Sales and retail assistants	Not STEM	2.32	-0.66
7112	Retail cashiers and check-out operators	Not STEM	1.10	-0.61
7113	Telephone salespersons	Not STEM	2.80	0.10
7114	Pharmacy and other dispensing assistants	Not STEM	2.85	-0.59
7121	Collector salespersons and credit agents	Not STEM	1.98	-0.78
7122	Debt, rent and other cash collectors	Not STEM	2.92	0.42
7123	Roundspersons and van salespersons	Not STEM	1.08	-1.15
7124	Market and street traders and assistants	Not STEM	2.51	-0.33
7125	Merchandisers and window dressers	Not STEM	3.21	-0.60

SOC10M	Description	STEM	Proportion of STEM graduates (%)	Index of STEM skills use
7129	Sales related occupations n.e.c.	Not STEM	4.70	-0.30
7130	Sales supervisors	Not STEM	2.47	-0.45
7211	Call and contact centre occupations	Not STEM	5.21	-0.33
7213	Telephonists	Not STEM	1.22	-1.29
7214	Communication operators	Not STEM	4.23	-0.67
7215	Market research interviewers	Not STEM	2.05	-1.89
7219	Customer service occupations n.e.c.	Not STEM	3.03	-0.15
7220	Customer service managers and supervisors	Not STEM	4.19	0.35
8111	Food, drink and tobacco process operatives	Not STEM	0.63	-0.69
8112	Glass and ceramics process operatives	Not STEM	0.00	-0.59
8113	Textile process operatives	Not STEM	0.58	-1.05
8114	Chemical and related process operatives	Not STEM	1.13	-0.15
8115	Rubber process operatives	Not STEM	0.00	-0.99
8116	Plastics process operatives	Not STEM	0.31	-0.69
8117	Metal making and treating process operatives	Not STEM	1.51	-0.52
8118	Electroplaters	Not STEM	0.00	-0.59
8119	Process operatives n.e.c.	Not STEM	0.13	-0.01
8121	Paper and wood machine operatives	Not STEM	0.00	-0.27
8122	Coal mine operatives	Not STEM	0.00	-0.24
8123	Quarry workers and related operatives	Not STEM	3.70	-0.24
8124	Energy plant operatives	Not STEM	4.18	-0.06
8125	Metal working machine operatives	Not STEM	0.38	-0.10
8126	Water and sewerage plant operatives	Not STEM	9.32	-0.24
8127	Printing machine assistants	Not STEM	0.80	-0.36
8129	Plant and machine operatives n.e.c.	Not STEM	0.00	-0.43
8131	Assemblers (electrical and electronic products)	Not STEM	1.86	-0.85
8132	Assemblers (vehicles and metal goods)	Not STEM	0.00	-0.38
8133	Routine inspectors and testers	Not STEM	5.39	-0.15
8134	Weighers, graders and sorters	Not STEM	0.59	-0.43
8135	Tyre, exhaust and windscreen fitters	Not STEM	0.00	-0.43
8137	Sewing machinists	Not STEM	0.14	-0.77
8139	Assemblers and routine operatives n.e.c.	Not STEM	0.78	-0.54
8141	Scaffolders, stagers and riggers	Not STEM	0.13	-0.33
8142	Road construction operatives	Not STEM	0.20	-0.78
8143	Rail construction and maintenance operatives	Not STEM	1.29	-0.26
8149	Construction operatives n.e.c.	Not STEM	1.50	-0.34
8211	Large goods vehicle drivers	Not STEM	0.65	-1.00
8212	Van drivers	Not STEM	0.99	-1.19
8213	Bus and coach drivers	Not STEM	0.57	-1.10
8214	Taxi and cab drivers and chauffeurs	Not STEM	1.20	-1.08
8215	Driving instructors	Not STEM	1.74	-0.46
8221	Crane drivers	Not STEM	0.00	-0.70
8222	Fork-lift truck drivers	Not STEM	0.00	-0.60
8223	Agricultural machinery drivers	Not STEM	1.92	-0.42
8229	Mobile machine drivers and operatives n.e.c.	Not STEM	0.55	-0.86
8231	Train and tram drivers	Not STEM	3.02	-0.01
8232	Marine and waterways transport operatives	Not STEM	5.27	-0.05
8233	Air transport operatives	Not STEM	4.32	-0.05
8234	Rail transport operatives	Not STEM	5.33	-0.05
8239	Other drivers and transport operatives n.e.c.	Not STEM	1.28	-0.05
9111	Farm workers	Not STEM	3.56	-0.87
9112	Forestry workers	Not STEM	4.72	-0.04
9119	Fishing and other elementary agriculture occupations n.e.c.	Not STEM	1.66	-1.05
9120	Elementary construction occupations	Not STEM	1.21	-0.71
9132	Industrial cleaning process occupations	Not STEM	0.46	-1.18
9134	Packers, bottlers, canners and fillers	Not STEM	0.64	-0.99
9139	Elementary process plant occupations n.e.c.	Not STEM	0.48	-0.78
9211	Postal workers, mail sorters, messengers and couriers	Not STEM	1.12	-1.08
9219	Elementary administration occupations n.e.c.	Not STEM	3.27	-0.70
9231	Window cleaners	Not STEM	0.12	-0.84
9232	Street cleaners	Not STEM	0.00	-1.13
9233	Cleaners and domestics	Not STEM	0.71	-1.52
9234	Launderers, dry cleaners and pressers	Not STEM	0.88	-0.96
9235	Refuse and salvage occupations	Not STEM	0.21	-1.15
9236	Vehicle valeters and cleaners	Not STEM	0.30	-1.99
9241	Security guards and related occupations	Not STEM	2.39	-0.23
9242	Parking and civil enforcement occupations	Not STEM	1.25	-0.59
9244	School midday and crossing patrol occupations	Not STEM	0.82	-1.57
9249	Elementary security occupations n.e.c.	Not STEM	2.51	0.29
9251	Shelf fillers	Not STEM	1.56	-1.28
9259	Elementary sales occupations n.e.c.	Not STEM	3.24	-0.96
9260	Elementary storage occupations	Not STEM	0.99	-0.62
9271	Hospital porters	Not STEM	0.00	-1.11

SOC10M	Description	STEM	Proportion of STEM graduates (%)	Index of STEM skills use
9272	Kitchen and catering assistants	Not STEM	1.08	-0.97
9273	Waiters and waitresses	Not STEM	1.74	-1.07
9274	Bar staff	Not STEM	2.52	-1.03
9275	Leisure and theme park attendants	Not STEM	3.73	-0.88
9279	Other elementary services occupations n.e.c.	Not STEM	3.37	-0.14

Source: UK Commission analysis based on Labour Force Survey and Skills and Employment Survey

Appendix B: Key labour market data for identified STEM occupations

Rank	Occupation	Job family	Employment 2012 (000s)	Projected employment change 2012-2022 (000s)	Projected job openings 2012-2022 (000s)	Gross median annual pay, 2013 (%)	Skill shortages as % vacancies, 2013
1	Programmers and software development professionals (2136)	IT professionals	277	56	146	38,486	41%
2	Production managers and directors in manufacturing (1121)	Managers (inc. production managers)	285	64	174	40,564	21%
3	IT specialist managers (2133)	IT professionals	210	43	111	43,423	41%
4	Information technology and telecommunications professionals n.e.c. (2139)	IT professionals	191	39	101	36,948	41%
5	Engineering professionals n.e.c. (2129)	Engineering professionals	100	21	53	38,929	58%
6	Mechanical engineers (2122)	Engineering professionals	94	19	50	40,477	58%
7	IT business analysts, architects and systems designers (2135)	IT professionals	113	23	60	40,398	41%
8	Design and development engineers (2126)	Engineering professionals	76	15	40	37,877	58%
9	Civil engineers (2121)	Engineering professionals	81	17	43	36,060	58%
10	IT project and programme managers (2134)	IT professionals	72	15	38	47,985	41%
11	Electrical engineers (2123)	Engineering professionals	47	10	25	42,609	58%
12	Production and process engineers (2127)	Engineering professionals	53	11	28	36,526	58%
13	Electronics engineers (2124)	Engineering professionals	40	8	21	37,768	58%
14	Information technology and telecommunications directors (1136)	IT professionals	60	14	37	55,426	15%
15	Quality assurance and regulatory professionals (2462)	Quality professionals	77	15	48	36,767	29%
16	Web design and development professionals (2137)	IT professionals	70	14	37	29,204	41%
17	Engineering technicians (3113)	Science, engineering, production, technicians	84	8	34	31,711	38%
18	Biological scientists and biochemists (2112)	Scientists	87	18	46	34,182	16%
19	Health and safety officers (3567)	Health and safety officers	51	9	28	32,001	36%
20	Research and development managers (2150)	R&D managers	42	9	22	43,618	14%
21	Quality control and planning engineers (2461)	Quality professionals	29	6	18	33,909	29%
22	Electrical and electronics technicians (3112)	Science, engineering, production, technicians	26	2	11	30,351	38%
23	Natural and social science professionals n.e.c. (2119)	Scientists	50	10	26	34,191	16%
24	Waste disposal and environmental services managers (1255)	Managers (inc. production managers)	18	2	10	37,212	24%
25	Building and civil engineering technicians (3114)	Science, engineering, production, technicians	15	1	6	28,785	38%
26	Planning, process and production technicians (3116)	Science, engineering, production, technicians	26	2	10	26,977	38%
27	Laboratory technicians (3111)	Science, engineering, production, technicians	76	7	30	19,005	38%
28	Production managers and directors in mining and energy (1123)	Managers (inc. production managers)	18	4	11	65,185	21%
29	Environment professionals (2142)	Environment / conservation professionals	40	8	21	31,057	20%
30	Science, engineering and production technicians n.e.c. (3119)	Science, engineering, production, technicians	34	3	14	24,934	38%

31	Environmental health professionals (2463)	Quality professionals	12	2	8	31,888	29%
32	Quality assurance technicians (3115)	Science, engineering, production, technicians	22	2	9	25,899	38%
33	Physical scientists (2113)	Scientists	25	5	13	52,470	16%
34	IT operations technicians (3131)	IT Technicians	111	10	45	27,209	13%
35	Chemical scientists (2111)	Scientists	32	7	17	32,469	16%
36	IT user support technicians (3132)	IT Technicians	84	7	34	27,132	13%
37	Conservation professionals (2141)	Environment / conservation professionals	16	3	8	30,010	20%
38	IT engineers (5245)	IT engineers	39	-3	9	25,789	31%

Sources: see Table 10, page 69.

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

			Z-scores				
Rank	Occupation	Job family	**Projected net change in employment**	**Projected job openings**	**Skill 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 professionals 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
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

			Z-scores				
Rank	Occupation	Job family	**Projected net change in employment**	**Projected job openings**	**Skill shortages**	**Median pay**	**Overall score**
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

Note: see section 5.3, page 70 for explanation of scoring approach.

Bibliography

BIS (2009) The demand for STEM skills, (produced by DIUS, Department for Innovation, Universities & Skills), London.

BIS (2011) STEM Graduates in Non-STEM Jobs, BIS Research Paper Number 30. Department for Business, Innovation and Skills. London.

BIS (2011a) Strategy for UK Life Sciences. Department for Business, Innovation and Skills. London.

BIS (2013) A UK Strategy for Agricultural Technologies. Department for Business, Innovation and Skills, London.

BIS (2013a) Driving Success – A Strategy for Growth and Sustainability in the UK Automotive Sector. Department for Business, Innovation and Skills., London.

BIS (2013b) Lifting Off – Implementing the Strategic Vision for UK Aerospace. Department for Business, Innovation and Skills., London.

BIS (2013c) Information Economy Strategy. Department for Business, Innovation and Skills., London.

BIS (2014) Insights from international benchmarking of the UK science and innovation system, BIS Analysis Paper Number 03. Department for Business, Innovation and Skills. London.

Bosworth, D., Lyonette, C., Wilson, R., Bayliss, M., Fathers, S. (2013). The supply of and demand for high-level STEM skills. Evidence Report 77, UK Commission for Employment and Skills, Wath-upon-Dearne.

Broughton, N (2013) In the Balance: The STEM human capital crunch. Social Market Foundation, London.

CBI (2013) Engineering our future: stepping up the urgency on STEM. Confederation of British Industry, London

CIHE (2009) The demand for STEM graduates: some benchmark projections (by IER, Warwick), Council for Industry and Higher Education, London.

Cornell University, INSEAD, and WIPO (2014): The Global Innovation Index 2014: The Human Factor In innovation, Fontainebleau, Ithaca, and Geneva.

Felstead, A. et al. , Skills and Employment Surveys Series Dataset, 1986, 1992, 1997, 2001, 2006 and 2012 [computer file]. 2nd Edition. Colchester, Essex: UK Data Archive [distributor], May 2014. SN: 7467 , http://dx.doi.org/10.5255/UKDA-SN-7467-2

Garrett, R., Campbell, M. and Mason, G. (2010) The Value of Skills: An Evidence Review. UK Commission for Employment and Skills, Wath-upon-Dearne.

Greenwood, C., Harrison, M., Vignoles, A. (2011) The labour market value of STEM qualifications and occupations. Institute of Education / Royal Academy of Engineering.

Harrison, M. (2012) FE STEM data project: November 2012 report. Royal Academy of Engineering, London.

House of Lords (2012). Higher Education in Science, Technology, Engineering and Mathematics (STEM) Subjects. Science and Technology Committee. HMSO. London.

Levy, C. and L. Hopkins (2010). Shaping Up For Innovation: are we Delivering the Right Skills for the 2020 Knowledge Economy. The Work Foundation. London.

Mason, G. (2011) Science, Engineering and Technology Technicians in the UK Economy. Gatsby Foundation, London.

Migration Advisory Committee (2013) Skilled,Shortage,Sensible: Full review of the recommended shortage occupation lists for the UK and Scotland, a sunset clause and the creative occupations. Migration Advisory Committee, London.

Porter, M. and S. Stern. (2002). National Innovative Capacity, The Global Competitiveness Report 2001-2002. Oxford University Press, New York and Oxford.

Royal Academy of Engineering (2012) Jobs and Growth: the Importance of Engineering Skills to the UK Economy. The Royal Academy of Engineering, London.

Semta (2010). UK Report: Sector Skills Assessment Report for Science, Engineering and Manufacturing Technologies. The Sector Skills Council for Science, Engineering and Manufacturing Technologies. Watford.

Störmer, E., Patscha, C., Prendergast, J., Daheim, C., Glover, P., and Beck, H. (2014) The future of work: Jobs and skills in 2030. Evidence Report 84, UK Commission for Employment and Skills, Wath-upon-Dearne.

Tech Partnership (2014) Big Data Analytics Assessment of Demand for Labour and Skills 2013–2020, SAS UK & Ireland, Marlow.

Wilson, R.A (2010) Lessons from America: a Research and Policy Briefing. UKCES Briefing Paper Series. Wath upon Dearne: UK Commission for Employment and Skills, Wath-upon-Dearne.

Wilson, R., Beaven, R., May-Gillings, M., Hay, G., and Stevens, J. (2014). *Working Futures*, 2012-2022. Evidence Report 83, UK Commission for Employment and Skills, Wath-upon-Dearne.

Wilson, R., Beaven, R., and May-Gillings, M. (2014b). *Working Futures*, 2012-2022: Technical report on sources and methods, UK Commission for Employment and Skills, Wath-upon-Dearne.

Winterbotham, M., Vivian, D., Shury, J., Davies, B., and Kik, G. (2014). The UK Commission's Employer Skills Survey 2013: UK Results. Evidence Report 81, UK Commission for Employment and Skills, Wath-upon-Dearne.

List of previous publications

Executive summaries and full versions of all these reports are available from www.ukces.org.uk

Evidence Report 1
Skills for the Workplace: Employer Perspectives

Evidence Report 2
***Working Futures* 2007-2017**

Evidence Report 3
Employee Demand for Skills: A Review of Evidence & Policy

Evidence Report 4
High Performance Working: A Synthesis of Key Literature

Evidence Report 5
High Performance Working: Developing a Survey Tool

Evidence Report 6
Review of Employer Collective Measures: A Conceptual Review from a Public Policy Perspective

Evidence Report 7
Review of Employer Collective Measures: Empirical Review

Evidence Report 8
Review of Employer Collective Measures: Policy Review

Evidence Report 9
Review of Employer Collective Measures: Policy Prioritisation

Evidence Report 10
Review of Employer Collective Measures: Final Report

Evidence Report 11
The Economic Value of Intermediate Vocational Education and Qualifications

Evidence Report 12
UK Employment and Skills Almanac 2009

Evidence Report 13
National Employer Skills Survey 2009: Key Findings

Evidence Report 14
Strategic Skills Needs in the Biomedical Sector: A Report for the National Strategic Skills Audit for England, 2010

Evidence Report 15
Strategic Skills Needs in the Financial Services Sector: A Report for the National Strategic Skills Audit for England, 2010

Evidence Report 16
Strategic Skills Needs in the Low carbon Energy generation Sector: A Report for the National Strategic Skills Audit for England, 2010

Evidence Report 17
Horizon Scanning and Scenario Building: Scenarios for Skills 2020

Evidence Report 18
High Performance Working: A Policy Review

Evidence Report 19
High Performance Working: Employer Case Studies

Evidence Report 20
A Theoretical Review of Skill Shortages and Skill Needs

Evidence Report 21
High Performance Working: Case Studies Analytical Report

Evidence Report 22
The Value of Skills: An Evidence Review

Evidence Report 23
National Employer Skills Survey for England 2009: Main Report

Evidence Report 24
Perspectives and Performance of Investors in People: A Literature Review

Evidence Report 25
UK Employer Perspectives Survey 2010

Evidence Report 26
UK Employment and Skills Almanac 2010

Evidence Report 27
Exploring Employer Behaviour in relation to Investors in People

Evidence Report 28
Investors in People - Research on the New Choices Approach

Evidence Report 29
Defining and Measuring Training Activity

Evidence Report 30
Product strategies, skills shortages and skill updating needs in England: New evidence from the National Employer Skills Survey, 2009

Evidence Report 31
Skills for Self-employment

Evidence Report 32
The impact of student and migrant employment on opportunities for low skilled people

Evidence Report 33
Rebalancing the Economy Sectorally and Spatially: An Evidence Review

Evidence Report 34
Maximising Employment and Skills in the Offshore Wind Supply Chain

Evidence Report 35
The Role of Career Adaptability in Skills Supply

Evidence Report 36
The Impact of Higher Education for Part-Time Students

Evidence Report 37
International approaches to high performance working

Evidence Report 38
The Role of Skills from Worklessness to Sustainable Employment with Progression

Evidence Report 39
Skills and Economic Performance: The Impact of Intangible Assets on UK Productivity Growth

Evidence Report 40
A Review of Occupational Regulation and its Impact

Evidence Report 41
***Working Futures* 2010-2020**

Evidence Report 42
International Approaches to the Development of Intermediate Level Skills and Apprenticeships

Evidence Report 43
Engaging low skilled employees in workplace learning

Evidence Report 44
Developing Occupational Skills Profiles for the UK

Evidence Report 45
UK Commission's Employer Skills Survey 2011: UK Results

Evidence Report 46
UK Commission's Employer Skills Survey 2011: England Results

Evidence Report 47
Understanding Training Levies

Evidence Report 48
Sector Skills Insights: Advanced Manufacturing

Evidence Report 49
Sector Skills Insights: Digital and Creative

Evidence Report 50
Sector Skills Insights: Construction
Evidence Report 51
Sector Skills Insights: Energy

Evidence Report 52
Sector Skills Insights: Health and Social Care

Evidence Report 53
Sector Skills Insights: Retail

Evidence Report 54
Research to support the evaluation of Investors in People: Employer Survey

Evidence Report 55
Sector Skills Insights: Tourism

Evidence Report 56
Sector Skills Insights: Professional and Business Services

Evidence Report 57
Sector Skills Insights: Education

Evidence Report 58
Evaluation of Investors in People: Employer Case Studies

Evidence Report 59
An Initial Formative Evaluation of Best Market Solutions

Evidence Report 60
UK Commission's Employer Skills Survey 2011: Northern Ireland National Report

Evidence Report 61
UK Skill levels and international competitiveness

Evidence Report 62
UK Commission's Employer Skills Survey 2011: Wales Results

Evidence Report 63
UK Commission's Employer Skills Survey 2011: Technical Report

Evidence Report 64
The UK Commission's Employer Perspectives Survey 2012

Evidence Report 65
UK Commission's Employer Skills Survey 2011: Scotland Results

Evidence Report 66
Understanding Employer Networks

Evidence Report 67
Understanding Occupational Regulation

Evidence Report 68
Research to support the Evaluation of Investors in People: Employer Survey (Year 2)

Evidence Report 69
Qualitative Evaluation of the Employer Investment Fund Phase 1

Evidence Report 70
Research to support the evaluation of Investors in People: employer case studies (Year 2)

Evidence Report 71
High Performance Working in the Employer Skills Surveys

Evidence Report 72
Training in Recession: The impact of the 2008-2009 recession on training at work

Evidence Report 73
Technology and skills in the Digital Industries

Evidence Report 74
Technology and skills in the Construction Industry

Evidence Report 75
Secondary analysis of employer surveys: Urban/rural differences in access and barriers to jobs and training

Evidence Report 76
Technology and Skills in the Aerospace and Automotive Industries

Evidence Report 77
Supply of and demand for High-Level STEM skills

Evidence Report 78
A Qualitative Evaluation of Demand-led Skills Solutions: Growth and Innovation Fund and Employer Investment Fund

Evidence Report 79
A Qualitative Evaluation of Demand-led Skills Solutions: standards and frameworks

Evidence Report 80
Forecasting the Benefits of the UK Commission's Programme of Investments

Evidence Report 81
UK Commission's Employer Skills Survey 2013: UK Results

Evidence Report 82
UK Commission's Employer Skills Survey 2013: Technical Report

Evidence Report 82
UK Commission's Employer Skills Survey 2013: Technical Report

Evidence Report 83
***Working Futures* 2012-2022**

Evidence Report 84
The Future of Work: Jobs and skills in 2030

Evidence Report 85
UK Skill Levels and International Competitiveness: an update

Evidence Report 86
Understanding Skills and Performance Challenges in the Logistics Sector

Evidence Report 87
Understanding Skills and Performance Challenges in the Wholesale and Retail Sector

Evidence Report 88
Employer Perspectives Survey 2014: UK results

Evidence Report 89
Careers of the Future: Background Report

Evidence Report 90
Sector insights: skills and performance challenges in the energy sector

Evidence Report 91
Sector insights: skills and performance challenges in the health and social care sector

Evidence Report 92
Sector insights: skills and performance challenges in the digital and creative sector

Evidence Report 93
Sector insights: skills and performance challenges in the advanced manufacturing sector

Evidence Reports present detailed findings of the research produced by the UK Commission for Employment and Skills. The reports contribute to the accumulation of knowledge and intelligence on skills and employment issues through the review of existing evidence or through primary research.

UKCES
Renaissance House
Adwick Park
Wath-upon-Dearne
Rotherham
S63 5NB
T +44 (0)1709 774 800
F +44 (0)1709 774 801

UKCES
Sanctuary Buildings
Great Smith St.
Westminster
London
SW1P 3BT
T +44 (0)20 7227 7800

This document is available at www.gov.uk/ukces

ISBN 978-1-908418-80-7