Engineering UK 2017

The state of engineering

EngineeringUK

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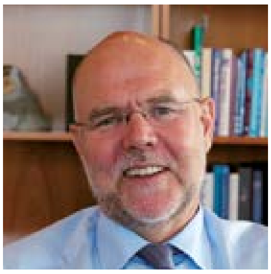
Engineering a better UK

Foreword



This annual report summarises how engineering contributes to the UK economy, and gives an in-depth analysis of the supply and demand trends in UK engineering talent.

The report is used extensively by policy-makers, educators and employers of current and future engineers. As such it is very important that the data are collated objectively, their quality assurance improved annually, and that the conclusions drawn in the Synopsis and main text are all solidly evidence-based, and not reflecting the agenda of any particular organisation.

That is why the Synopsis and text that comprise this report are deliberately limited to data and fact-based modelling and conclusions, which are open to all to interpret and draw upon. The main body of the report is a "public good", and EngineeringUK hopes it will be increasingly referenced and used.

This Foreword is different. It reflects the joint recommendations of the undersigned, being respectively President of the Royal Academy of Engineering and Chair of EngineeringUK. These are our personal recommendations, informed by the findings in the Report and directed at all those interested in the future of the UK, and the immense role that engineering and technology currently plays, and needs to play in post-Brexit Britain. We do not claim they reflect the consensus views of the entire engineering sector. But we do think they shine a powerful light on the best way forward to ensure engineering has the supply of talent to contribute to the UK in the critically important way that it should.

The report highlights that:

- Engineering contributes 26% of the UK's GDP – viewed in terms of Gross Value Added, its contribution is more than that of the retail and wholesale and financial and insurance sectors combined
- Engineering activity has a particularly high wider employment multiplier effect: every extra person employed in engineering supports another 1.74 other jobs

As the global economy evolves and Britain prepares for a new future, engineering and technology will play an ever more vital role in driving our economy, creating employment, building the essential infrastructure to compete in the modern world, and enabling a higher quality of life for all: from cleaner air in cities to faster broadband; from growth of high-tech start-ups to more energy-efficient homes.

This will be a tough world in which to compete: the underlying trend towards the "hourglass economy" predicts increasing demand for highly skilled jobs which leverage a strong "STEM" (Science, Technology, Engineering and Maths) skills set, and fast growth of knowledge-based services. There are some positive signs among the data in this report:

- 9% more engineering and technology first degrees obtained in 2014/15 than the year before

- Highest number of engineering related apprenticeship starts in England for ten years
- More 11-16 year olds "would consider a career in engineering" (up from 40% to 51% in four years).

But there continue to be real concerns, which highlight why efforts should be redoubled to improve STEM education, to attract young people into engineering, and to retain, motivate and improve the skills of those already in engineering:

- Engineering graduate supply falls well short of demand: we conclude from the report, a shortfall of at least 20,000 annually (and likely higher, depending on assumptions)
- We are highly dependent on attracting and retaining international talent from the EU and beyond to help meet this shortfall: a vital part of post-Brexit policies
- Our postgraduate engineering and technology degrees are successful internationally, but the proportion of UK-domiciled graduates is becoming too low to be sustainable in the long-term (down to 25% of taught engineering and technology postgraduate qualifications, in 2014/15)
- Efforts to attract girls and women into engineering are falling short: today less than 1 in 8 of the engineering workforce is female; boys are 3.5 times more likely to study A level Physics (in England, Wales and Northern Ireland) than girls; and five times more likely to gain an engineering and technology degree.

This is the backdrop to our recommendations, above all:

- To promote the role and contribution of engineering and technology to the UK
- To improve the UK supply of engineers, and of engineering and technology skills

And in particular:

1. Encourage many more pupils to choose STEM subjects and make well-informed choices that maintain the option of a career in engineering and technology
2. Increase diversity in engineering and technology, through the entire education system and into and throughout employment
3. Draw on the talent already in the workforce: increase the skills, and improve the retention, of existing engineering employees – and attract employees from other sectors
4. Enhance the vital international dimension in UK Higher Education: world-class, welcoming and open for study – and subsequent employment
5. Develop an industrial strategy that reinforces and sustains engineering's contributions to the UK, and that recognises and helps to address the STEM skills gap

We hope these recommendations resonate with all those who dip into this report or use it at some length. We also hope that they will influence the agendas of everyone involved in the relevant aspects of Government, education and employment, and so help to galvanise more action, for the good of the UK economy and for future generations.

Professor Dame Ann Dowling
President of the Royal Academy of Engineering

Malcolm Brinded
Chairman, EngineeringUK

The backdrop to our recommendations are two headline themes:

1. Promote the role and contribution of engineering and technology to the UK.
2. Improve the supply of engineers, and of engineering and technology skills.

Recommendations

These recommendations are intended for all those organisations that have a role in the supply of future engineering and technology talent for the UK economy, or in the employment of engineers in the UK.

They reflect the need for a wide-ranging, vigorous and concerted response from a broad spectrum of organisations: government at all levels; employers; schools; further and higher education; professional engineering organisations; and providers of education support and enrichment.

1. **Encourage many more pupils to choose STEM subjects and make well-informed choices that maintain the option of a career in engineering and technology**
    - Enable all young people to follow a broader curriculum up to the age of 18
    - Develop an inspirational and aspirational image of engineering and communicate it through appropriate channels to young people and their influencers
    - Increase, focus and better coordinate the engagement of employers with schools and young people to make it more systematic and effective, reducing duplication and reaching schools that are currently under-served
    - Enhance STEM-related careers support in schools
    - Urgently address the significant shortage of specialist teachers in physics, design and technology and computing
    - Develop accountability measures on schools that increase participation in practical, technical and creative subjects that support engineering skills
    - Diversify the pathways to engineering employment post-education, especially through further encouraging apprenticeships, including at degree level
    - Provide UCAS-style support for vocational education

2. **Increase diversity in engineering and technology, through the entire education system, into and throughout employment**
    - Increase research into engineering graduate decisions, destinations and incomes for women and ethnic minority groups
    - Develop strategies to improve diversity and inclusion in STEM choices from school into higher, technical and vocational education
    - Promote subject choices in ways which radically improve the diversity of those studying STEM A Level subjects
    - Significantly increase the routes into engineering and technology degrees for those without A level physics

- Develop more inclusive cultures across education establishments to support the retention and successful attainment of female and other groups currently underrepresented in engineering and technology
- Very significantly improve attraction of women and black and minority ethnic people into apprenticeships
- Develop more active and inclusive recruitment approaches, promoting engineering to diverse candidates and focusing on future potential
- Develop workplace cultures that include and retain women, ethnic minority people and other underrepresented groups.

3. Draw on the talent already in the workforce: increase the skills, and improve the retention, of existing engineering employees – and attract employees from other sectors

- Understand better the flows of people between sectors and the potential to increase the numbers returning to engineering e.g. from career breaks
- Resource and diversify new pathways into engineering to retrain or up-skill those already in the workforce
- Encourage a more diverse range of people to consider switching to a career (at any time during their working life) in the engineering and technology sectors

4. Enhance the vital international dimension in UK Higher Education: world-class, welcoming and open for study – and subsequent employment

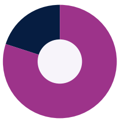
- Actively promote our world-leading STEM Higher Education experience
- Remove international undergraduate and postgraduate students from UK net migration targets
- Enable more well-qualified international engineering students to enter post-study employment in the UK

5. Develop an industrial strategy that reinforces and sustains the contribution of engineering to the UK, and that recognises and helps to address the STEM skills gap

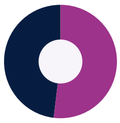
- Prioritise and invest to increase the STEM skills supply in quantity, quality and diversity
- Enable continued inward migration of skilled engineering and technology talent to support the indigenous UK engineering sector and global enterprises investing in the UK

Synopsis
Engineering: context and contributions

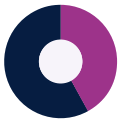
Engineering plays a vital role in the UK's economic and societal wellbeing, providing quality employment on a large scale and enabling the majority of our physical exports, as well as developing and implementing some of the key solutions to major global challenges. The UK engineering base has a world-leading position in a range of the knowledge-intensive industrial sub-sectors responding to global challenges, as well as in the scientific and technological research and innovation that underpin them.



80%
of engineering enterprises have **four** or fewer employees



52%
of employees work in an enterprise with **100** or more people



42%
of employees work in an enterprise with **250** or more people

Economy

Analysis by the Centre for Economics and Business Research (Cebr) suggests that the gross value added (GVA) for the UK by the engineering sector, as defined by EngineeringUK's Footprint of engineering jobs and companies, was £433 billion in 2015.

This was more than some key comparable sectors of the economy, including retail and wholesale, financial and insurance combined. From this GVA figure, it is estimated that engineering contributed £486 billion to UK GDP in 2015 – around 26% of the total and representing 2.3% growth since 2014. Furthermore every additional £1 of GVA created by engineering activity creates an additional £1.45 of GVA through indirect effects on the supply chain and more widely on household incomes and employment: engineering activity has a multiplier effect of 2.45 on GVA. In terms of effects on employment, every additional person employed in engineering, supports an additional 1.74 jobs: a multiplier effect of 2.74.

In 2015, the number of engineering enterprises in the UK grew by 7% over the previous year, to 650,000. Relative growth was fastest in London although experienced in every region and largely keeping pace with the backdrop of overall growth across the UK.

Small employers dominate numerically: 80% of registered engineering enterprises have four or fewer employees. However, the majority (52%) of employees in 2015 worked for an enterprise which employed 100 or more people and most of those (42%) worked for an enterprise with 250 or more employees (9350 of which in the UK).

£486 billion
contributed by engineering to UK GDP in 2015

7% rise (to 650,000)
in 2015 in the number of UK engineering enterprises

1.74 jobs
supported by every person employed in engineering (a multiplier effect of 2.74)

5.7 million
employees work in registered engineering enterprises in the UK –
19%
of total UK employment

Employment

Nearly 5.7 million employees work in engineering enterprises in the UK, representing just over 19% of total UK employment in all registered enterprises. As a proportion of total employment, this has remained relatively consistent for the last three years.

The engineering workforce is getting older, but not significantly faster than in the UK economy overall. However, the proportion of young workers (aged under 25, especially) has been decreasing over the last ten years. While women make up 46% of the UK workforce as a whole, engineering continues to be male-dominated: women make up only 1 in 8 of those in engineering occupations and less than 1 in 10 of those in an engineering role within an engineering company.

Engineering workforce

Only 1 in 8
of those in engineering occupations are women

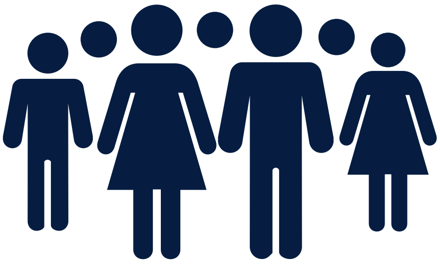
Context

Manufacturing remains one of the UK's largest economic sectors, despite automation having reduced its employment footprint.

It requires continued investment in innovation to consolidate the development of advanced manufacturing technology and concepts such as Industry 4.0. Some 2.7 million people are directly employed in the UK's manufacturing industries, and it is responsible for around half of the UK's exports. Over two-thirds of UK business investment in research and development is in manufacturing.

Productivity growth, which is a determinant of higher wages and improved sustainable output and therefore key to improving real wage growth, has been relatively weak in the UK since the recession, and lower than that of comparator nations. Technological innovation and investment in upskilling the labour force are thought to be crucial to enhance levels of productivity in engineering and manufacturing, and to respond to the re-shaping of the economy which will favour those with high skills.

The government's development of an industrial strategy is welcomed by the engineering community. It would endorse the view that a significant 'horizontal' element to such an industrial strategy – underpinning investments to assure increasing levels of skills, improved infrastructure, empowered science and research, and embedded innovation is a necessary adjunct to a strategic focus on key sectors or technologies. These feature in the ten pillars of the government's industrial strategy consultation (green) paper. Such an industrial strategy will be key to delivering an environment in which engineering can contribute effectively to economic and social development, particularly in light of the decision to leave the European Union, and should deliver a powerful message that the UK is forward looking, open for business, and an active and welcoming partner for the international research, innovation and business communities.



Future forecast:

265,000

skilled entrants required annually to meet demand for engineering enterprises through to 2024

Skills supply and demand

The broader international labour market landscape shows an underlying trend towards what is recognised as the 'hourglass economy'.

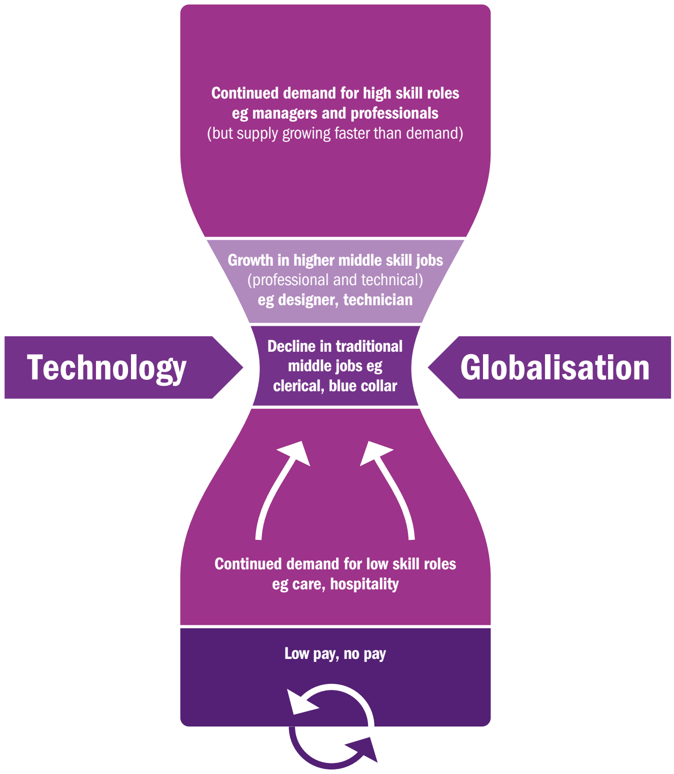
This predicts decreasing demand for 'blue collar' jobs (intermediate skills) which are vulnerable to automation and off-shoring. It also predicts increasing demand for lower skilled jobs (especially driven in health and social care by an ageing population) and for highly skilled jobs (technician and above) requiring science, technology, engineering and maths based competences. This is already being reflected in employers' reports of skills shortages and the government's shortage occupation list for skilled immigrants. This situation is expected to be exacerbated by the growth of new industries, some of which scarcely yet exist, emerging from new technologies and knowledge.

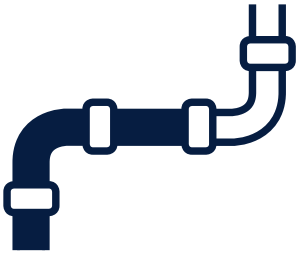
There is consistent evidence (including from the UK Commission for Employment and Skills, the CBI and the IET) of skills shortages for employers in key UK engineering sectors that are expanding, especially construction and ICT, as well as with manufacturing, despite its total size shrinking through automation. Employers anticipate an increasing need for people with higher level skills, and express decreasing confidence in their ability to recruit these in sufficient numbers. Potential restrictions on the free movement of labour, following the EU referendum result, further highlight skills shortage issues.

Retention of employees is becoming a higher priority for employers as the workforce becomes more highly trained and skilled. For example, the EEF found that approximately half of companies surveyed offer training plans and opportunities to work across other areas of the business to increase retention.

The broader international labour market shows an underlying trend towards what is recognised as the

'hourglass economy'





20,000
annual shortfall of engineering graduates (conservative estimate)

Latest labour force projections contained in Working Futures 2014-2024 predict annual growth in total employment of 0.5% for the UK. Projections for the engineering sector developed by University of Warwick's Institute for Employment Research from a bespoke extension of Working Futures 2014-2024 forecasts there will be demand in engineering enterprises for 265,000 skilled entrants annually through to 2024, of which around 186,000 will be needed in engineering occupations, to meet both replacement and expansion demand.

The total size of employment for those with level 3[1] skills will shrink, although significant replacement demand of around 57,000 entrants per year at this level will remain. At level 4[2] and higher, the annual requirement for engineering occupations is expected to be just over 101,000 annually. The demand will be particularly acute in construction, but also strong across the science and engineering, ICT and manufacturing sectors, and especially in London and the South East of England, although there will be net demand in all UK nations and regions.

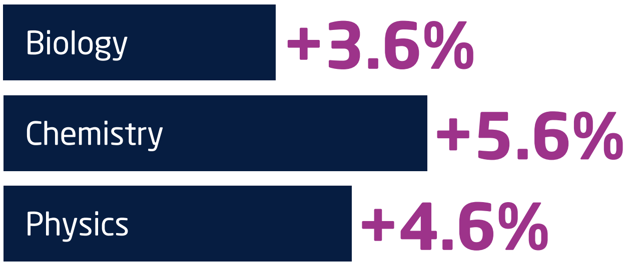
EngineeringUK's model for the supply of entrants into engineering roles with level 4+ skills, through higher education and higher-level apprenticeships, projects that there will be around 41,000 entrants of UK nationality annually. Our estimates of the supply from EU and other international graduates, based on our historic model, project the potential addition of up to a further 40,000 graduates, comprising a total of just over 81,000. This projection of supply assumes that similar numbers of international students will continue to study in the UK and continue to (be eligible to) work in engineering in the UK. Based on these estimates and assumptions, projected supply will fall short of demand by at least 20,000 per year.

Although the implications of the UK's intention to leave the EU have not been modelled, it seems likely that this will affect both sides of the supply/demand equation. In terms of supply, any tightening of immigration policy or reduction to the perceived attractiveness of studying and working in the UK, or eligibility to do so, are likely to have detrimental impacts on the supply of these key skills. If supply of entrants to engineering roles were from UK nationals only at level 4+ we would fall far further below the projected requirement. Work will take place over the next year to refine the current model of supply and we aim to provide an updated projection in the 2018 Report.

The supply of postgraduate-level skills in engineering and computing is currently highly dependent on international graduates studying in the UK, more so than any other major higher education discipline, and this represents a particular vulnerability.

1 For the purposes of this synopsis, we use the term level 3 to indicate academic and vocational qualifications or courses typically taken during upper secondary education (post 16) across England, Northern Ireland, Scotland and Wales. This includes but is not limited to A levels, Advanced Apprenticeships and equates to the same level in the Scottish Credit and Qualifications Framework containing Highers.
2 For the purposes of this synopsis, we use the term level 4+ as shorthand to include those academic and vocational qualifications that are typically taken after secondary education across England, Northern Ireland, Scotland and Wales and recognise progression into and through specialist, professional and higher education. This includes but is not limited to Higher National Certificates, Higher Apprenticeships, higher national diplomas, degree apprenticeships, degrees at all levels

Increase in GSCE entries 2015-2016



Educational context

Demographic trends

The UK population is set to grow from its current 66 million by around 3% in the next five years and by 11% in the next twenty, potentially reaching 73 million by 2037. Population growth has recently been, and is expected to continue to be, focused in London and South East England, with weaker growth in northern England, Wales and Scotland. Within the working population, 11% are not of UK nationality, and in the year to 2015, the non-UK workforce grew by 7.5% (compared with 1.5% growth in the UK workforce). This is largely attributable to immigration from European Union countries.

The number of secondary school-aged children in the UK is now rising and will continue to do so by around 10% over the next five years. This provides an expanding school cohort who can be encouraged to study the subjects that could enable them to pursue engineering careers. Similarly we are reaching the end of a period of decline in the number of young people aged 16-18; this will bottom out in 2018 and then begin to rise quite quickly.

Secondary level education

The number of schools is rising in response to these shifts in population, with some 3.8 million children currently educated in state-maintained secondary schools. While there has been a rise in the number of primary school teachers, this is not the case in the secondary sector.

The secondary education landscape continues to be complex, with policy-driven changes to structures (especially in England) and qualifications (across the UK nations). Generally, educational outcomes are improving overall, although the picture in terms of this supporting social mobility is very mixed: young people in London and its commuter belt are more likely to obtain good educational outcomes and have better career opportunities than those in the rest of the UK.

Following a period of decline during which the number of 16 year-olds was also falling, there has been a recent upturn in entries to individual science (physics, chemistry, biology) GCSE examinations. While entrants to design & technology and ICT are falling fast, there has been a rise in the numbers studying computing at GCSE level.

The overall GCSE pass rate fell back by 2 percentage points in 2016, thought to be partly due to recent changes in the English educational system relating to school performance measurement. Pass rates in single science subjects continue to be much higher (over 90%), than in combined science examinations (57%), reflecting the different types of schools and pupils taking these subjects. In 2016, there were fewer than 145,000 entries for each of the single science subjects, less than half the number for combined science (408,000 entries).

There have been rises in the number of entries to science and mathematics at A-level, and proportionally greater rises in computing and further mathematics albeit from smaller numbers. The rate of increase is slightly greater amongst females than males, but female students remain in the minority in computing (9.8% of entries), physics (21.6%) and further mathematics (27.5%) especially. There has been a slight dip in the numbers passing A-levels in science subjects but this is mostly due to a decreasing cohort size.

Results trends in Wales and Northern Ireland are broadly similar to those in England, while in Scotland trends will become clearer once the new Scottish National 5, Higher and Advanced Higher qualifications are fully bedded in.

The number of BTEC and similar vocational qualifications taken in addition to or instead of A-levels has risen fast in recent years, and has powered much of the increase in university entry by those from less advantaged backgrounds. The number of young people studying engineering and ICT (at level 3) have risen to the point where they are now similar to the number taking A-levels such as physics or computing.

While the number of GCSE entrants in sciences has grown over the last five years, the number of teachers teaching them has shrunk. A growing proportion of those teaching science subjects either have a degree in the subject or have had specific training in teaching the discipline. However secondary-level teacher shortages continue across the four nations, especially in physics, further mathematics and computing with these shortages felt most strongly in schools teaching combined sciences. Teaching computing as a subject has been recognised as a particular problem and the government is proposing to add it to the 'shortage occupation list' along with mathematics, chemistry and physics teachers, enabling easier immigration of such professionals to the UK

108,000

engineering apprenticeship starts (England) in 2014/15, the highest for ten years

Apprenticeships and Further Education

The current emphasis of education and skills policy is on apprenticeships rather than further education (FE), resulting in a sense of the FE sector being at something of a crossroads. The government is currently looking at 'technical education' and is working to restructure and simplify what has become overly complex in terms of its competing qualifications frameworks and pathways.

Meanwhile the number of vocational qualifications obtained in FE colleges is falling, reflected in a fall in the total number of colleges following mergers and closures. In spite of this, the number of engineering-related vocational qualifications obtained is actually rising, especially at the higher levels that are desirable in pathways towards a higher skilled technical labour force.

The government has loudly stated ambitions for growth in apprenticeship numbers, seeking three million starts during this parliament. Closer examination shows that there was a 15% growth in total starts in England in the year to 2014/15, with 108,000 in engineering sectors, the highest for ten years. Engineering-related apprenticeships are most prevalent in the North West, West Midlands and South East England, but not in London.

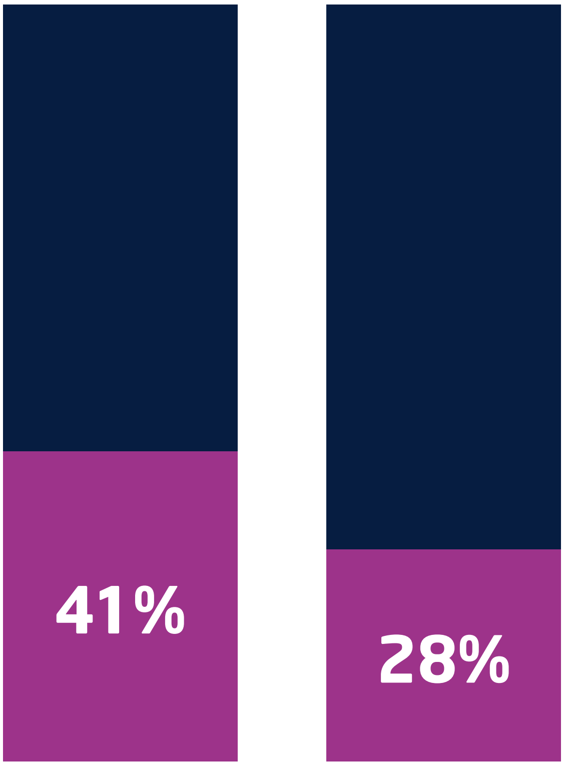
In 2014/15, 58,000 such apprenticeships were achieved in England, 42% of them at Level 3 or above. There was growth too in Scotland and Wales, but in Northern Ireland changes to funding entitlements for older workers have reduced the total numbers. Growth in engineering-related frameworks and ICT is proportionally strongest in Higher Apprenticeships, and the profile is shifting towards higher levels, more than is the case for many other sectors where Level 2 numbers continue to dominate. The age of starters is also decreasing for engineering, with 41% of starters aged under 19, in contrast to the overall apprenticeship picture where around half are over 25 years of age. On the other hand very few (7%) engineering-related apprentices are female, and in some frameworks only 3%.

A quarter of a million workplaces now offer apprenticeships, a rise of nearly 5% in a year and 50% over five years. 4 out of 5 manufacturing employers are reported to be planning to recruit manufacturing and engineering apprentices in the next year.

There are trends both for apprentice recruits to be younger and also for the balance of apprenticeship recruitment to be shifting towards higher levels, both of which are welcome trends, at which engineering is at the forefront. Productivity gains are highest from young apprentices.

Degree Apprenticeships are under a great deal of scrutiny and the first schemes have launched including in manufacturing and engineering sectors. As a means for a student to obtain a university degree without paying tuition fees and while earning a salary as an employee, they offer great promise as an alternative to traditional campus-based higher education. The introduction of the Apprenticeship Levy in 2017 may well catalyse the scale of their development, and engineering would do well to embrace them.

Apprenticeships starters aged under 19



Engineering apprenticeships

All apprenticeships

5%

growth in applicants to HE engineering courses in 2015/16

3%

growth in applicants to all HE course areas in 2015/16

Higher education

UK higher education (HE) has been booming in recent years with strong growth in first degree and postgraduate education, although this is counterbalanced by reduced numbers on some other undergraduate programmes and part-time study. Record levels of young people are entering HE for full-time study in England and Wales especially, but the number of people studying part-time has fallen sharply in recent years, reducing the extent to which this route is upskilling employed adults.

Trends showed nearly 5% growth in the number of applicants to engineering courses over the past year, greater than the 2.7% experienced across all subjects, with gains in all its sub-disciplines except electrical and electronic. Growth was marginally stronger amongst female applicants, although they remain the minority across engineering, albeit with higher proportions (over 25%) in general engineering and the growing area of chemical, process and energy engineering.

The majority (71%) of those entering a first degree in engineering and technology in 2014/15 were of UK origin, 6% from other EU countries and 23% from other nations. The proportions of international students within engineering and computer science are higher than for other STEM subjects. UK students with an ethnic minority origin are slightly over-represented in engineering, but females strongly under-represented at around 15% on average. Participation in other forms of undergraduate study such as HND and HNC programmes are falling, in parallel with the decrease in part-time HE participation.

At postgraduate level the picture is quite different, with only 25% of taught postgraduates in engineering being of UK origin, 15% from EU nations and 60% outside the EU. For some engineering sub-disciplines the proportion of international (non UK/EU) students has hit 80%. A quarter of all taught postgraduate students are female, reflecting a relatively greater tendency for female engineering graduates to pursue postgraduate study rather than enter engineering employment following their first degree.

In total, 9% more first degrees in engineering and technology were obtained in 2014/15 than the previous year. The strongest growth was in mechanical and aerospace engineering, while the numbers obtaining civil and also electrical and electronic engineering first degrees fell back. At Masters level, there was 15% growth, with three-quarters of standalone M-level engineering degrees obtained by non-UK graduates, and 86% of those in electrical and electronic engineering. Around 3000 doctorates were obtained, the majority (60%) by international students.

The strongly international composition of HE study in engineering (and computer science) stands out from other subjects, and poses some vulnerability both to any changes in future immigration policy with regard to international study or eligibility for post-study employment, and to perceptions of the UK by prospective international students. Postgraduate provision would in many cases not be viable without the participation of international students, who in turn become a high proportion of the HE research and teaching workforce in these strategically important subjects.

The decrease in part-time study is concerning as a potential route to upskill existing employees or those not in a position to undertake full-time degree study. Degree Apprenticeships represent an opportunity to offset this. Maintaining and ideally increasing the flow of graduates in engineering from HE is critical to the future skills supply pipeline for the sector. To do so seems likely to require continuation of the current participation of international students as well as increasing the UK student cohort. Better diversity of that cohort, in terms of gender but also a wider range of modes of study (including part-time models) would be of benefit.

68%
of UK first degree engineering graduates are in full-time work six months after graduation (2014/15)

84%
Three years after graduation, 84% are in full-time work and only 2% unemployed (2013/14)

Transition to employment

Graduate outcomes

Graduate employment rates rose post-recession and graduates as a whole have continued to enjoy higher employment rates and earnings than those without a degree, despite the strong expansion in graduate numbers.

A higher proportion of UK first degree engineering and technology graduates (68%) are in full-time employment six months after graduation than of graduates overall (58%), although fewer enter part-time work or postgraduate study. This proportion has risen over the last five years, tracking the improvement in the economy, post-recession. Three years after graduation, 84% are in full-time work and only 2% unemployed. Outcomes for those studying taught postgraduate engineering courses are more positive still, with three quarters in full-time employment soon after graduation.

Amongst UK engineering graduates who studied a first degree full-time, the proportions of men and women who enter full-time work six months after graduation are similar. A higher proportion of females enter postgraduate study than males.

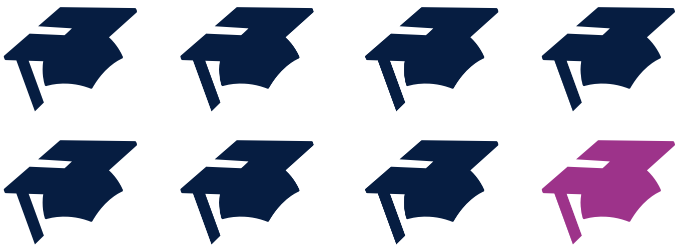
There is a larger variance with ethnicity in the employment outcomes of engineering graduates than amongst graduates overall. 71% of white engineering graduates are in full-time work within six months of graduation but only 51% of their counterparts of ethnic minority origin (compared to 59% and 53% for graduates from all subjects). Unemployment is also more than twice as high amongst the latter.

Of those UK and EU engineering graduates who enter employment after graduating from a UK full-time first degree, over 70% work in an engineering occupation; the proportion amongst those who study part-time is significantly higher still. The proportion of engineering graduates entering sectors such as financial services or management consultancy is tiny in comparison with the proportions entering work in engineering in occupations such as mechanical, civil or design engineers.

Graduates of other subjects also contribute significantly to the engineering workforce; roughly 1 in 8 of all employed first-degree graduates works in an engineering occupation six months after graduation – around 8,000 engineering graduates and 17,000 others.

Strategies to increase the employability of graduates are now embedded across HE providers, but there are some concerns (reported in the Wakeham review and elsewhere) that although STEM graduates are in high demand, not all have a sufficiently rounded set of both technical and transferable skills, at the right levels, to satisfy the demands of current employers. Work experience has become an essential asset for graduates.

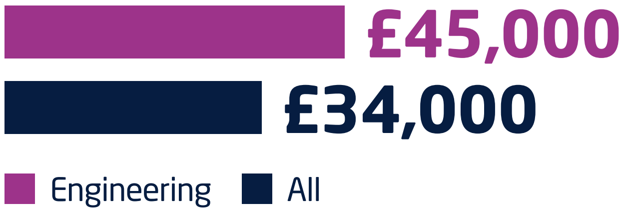
Graduates of other subjects



1 in 8
of all employed first-degree graduates work in an engineering occupation six months after graduation.

Graduates

Professionals



Earnings

Engineering graduate starting salaries are well above the all-subject average (£22,000) at just over £26,000 in 2014/15, and nearly £27,000 for those entering an engineering occupation. Postgraduate study adds a further premium.

Across all engineering disciplines, there is no gender pay gap in the mean starting salaries earned by graduates, although it does emerge in some sub-disciplines, and there is evidence for a small ethnicity pay gap for engineering graduates. There are also significant variances based on the type of university attended, more so for engineering than other subjects.

The mean salary, in 2015, for all those in full-time STEM occupation employment was £33,689, only 0.5% higher than the previous year, but the more representative median (£27,645) was up 1.6%. Amongst these occupations, mean earnings for some mainstream engineering roles look strong and are enjoying bigger rises – such as civil engineers at over £42,500 (up 5%) and mechanical engineers (over £45,000, up 3.6%) while electrical engineers had similar earnings but which declined last year. These are similar to, or higher than, the average for chartered and certified accountants.

At technician and skilled crafts levels, median salaries for many engineering-related roles are good and rising. Although they do not match earnings in the financial/business services sectors, many are considerably better than for some of the skilled roles in sectors such as the food and drink or textiles industries.

There are strong regional variations in earnings for those in engineering occupations, in line with overall trends. Those in London earn the most but mean engineering salaries are growing in all the home nations and English regions. However, these regional trends can be outweighed by more specific occupational variances regionally – in 2015, mean earnings for several engineering roles were higher outside London, reflecting local complexities of the labour market and in places key skills shortages.

2016

51%

Increasing rates of 11-16 year olds would consider a career in engineering

Increasing the flow

Perceptions of engineering as a career choice

Young people's perceptions of engineering have grown more positive in the last five years. The proportion of 11-16 year olds who would consider a career in engineering has risen from 40% in 2012 to 51% in 2016. This upward trend is somewhat more pronounced among those aged 11-14 than 15-16, and is rising faster still amongst those of sixth form age (17-19).

The picture amongst those who influence young people, educators, is also positive – the vast majority of teachers (96%) would recommend a career in engineering to their pupils, and three quarters of parents view engineering positively as a career. However, while parents are equally likely to recommend a vocational route into engineering as an academic one, pupils and teachers are more likely to favour academic routes into engineering.

A further concern is that teachers seem to have greater confidence in their pupils' knowledge of engineering than the pupils do themselves. In 2016 45% of STEM educators believed their pupils know what people in engineering do, but fewer than one third of young people claim to do so. Engineering is the area of work relating to STEM that they know the least about.

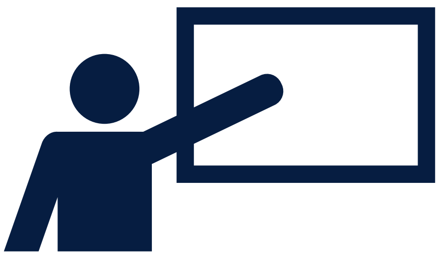
There is evidence that more positive attitudes towards STEM careers are having impact on subject choices in school; nonetheless, too few young people are deciding to continue to study the subjects that keep the doors open to engineering careers, limiting the number who ultimately will be able to enter highly-skilled engineering careers. Analysis of findings from large-scale studies suggests that higher priority should be given to addressing misconceptions about where STEM study can lead and highlighting its relevance to young people's current life and future direction. Interventions that focus too narrowly on improving enjoyment of STEM, it is suggested, often lack long-term impact on pupils' subject choices.

Effective careers education and interventions during school are vital to develop more informed careers thinking, and there is increasing agreement on how to deliver it well. Good careers support engages a wider variety of young people (including more from disadvantaged groups) to think more about their subject and career choices, not just those with the most social capital. However, careers advice and guidance in state schools remains patchy at best and highly under-resourced; indications are the majority of pupils currently do not have access to substantive careers guidance.

There is a necessary and growing focus on the quality and impact of interventions for young people, especially in schools. There are myriad offers and opportunities to schools of activities relating to STEM and related careers, which schools struggle to differentiate. STEM-related learning and communication activities need to be better co-ordinated and evaluated, so that schools can work out which are best to use and when and so that the activities achieve greater reach and long-term impact on young people.

Effective employer engagement

The shift away from professional careers support in schools in favour of employer engagement continues, based on the potential value of people from local business supporting career and employability development work in schools. There is emerging evidence (from the Education and Employers Taskforce) that effective interactions between young people and those in the world of work through structured employer engagement has an important role in helping young people make good decisions, and that participation in such activity (particularly in Key Stage 3) can have a discernible impact on their earnings in adult life. There is some divergence in the evidence of just how many employers are engaging with young people in education, through provision of school visits, careers talks and offers of work experience opportunities. However, the available data point towards growth in the proportion of engineering employers that are doing this.



96%

of teachers would recommend a career in engineering to their pupils

What's key

To maintain the economic and social contributions of engineering, we must address the shortfall of engineers

Emerging themes

This report establishes unequivocally the importance of engineering in terms of the contribution it makes to the UK in terms of economic activity and exports, providing large-scale employment, as well as societal impacts. The UK benefits from the particularly successful export activity of engineering, continuation of which will be reliant on the maintenance of open markets for the export of goods, services and education and the import of skilled labour.

We also project that the current rate of supply of high-level skills will not satisfy the expected demand over the next ten years. In order that such a shortfall does not damage engineering's ability to contribute in these important ways in future, we identify the following five areas:

1 **Increasing the supply pipeline (of engineers) from education**

2 **Increasing diversity**

3 **Increasing the supply of skills through the workforce**

4 **Maintaining the international dimension**

5 **Industrial strategy**

Engineering

For practical purposes, including for this report, we define engineering as a broad sector through a selection of industries and/or as a range of job types through a selection of occupations. These are selected from the ONS Standard Occupational Classification 2010 (jobs) and the Standard Industrial Classification 2007 (companies). Together these selections form EngineeringUK's 'Engineering footprint' – the occupational and industrial codes included are listed in the Annex to the report. While the selection is EngineeringUK's own it has been done in consultation with the Engineering Council and the Royal Academy of Engineering; it takes a relatively broad definition of engineering, particularly in terms of industries. At its core are engineering jobs that are in engineering companies ("SIC X SOC"), but the footprint also includes engineering jobs that are in non-engineering companies and non-engineering jobs that are in engineering companies.

Engineering UK 2017
Contents

Back to Contents

Engineering UK 2017
Figures and Tables

General notes on tables in this report

1. Numbers have been rounded in some tables either to the nearest 1000, nearest 10 or nearest 5
2. Percentages are based on numbers prior to rounding but themselves may not sum to 100% because of rounding errors to the nearest 0.5
3. 'level' refers to Regulated Qualifications Framework (RQF) level
4. '%p' refers to percentage point
5. '-' indicates that data is either not applicable, is missing or is below a reporting threshold and has been suppressed to protect the identities of the people to which the data applies and prevent the overinterpretation of small numbers
6. Figures relating to HESA data have been weigted by full-person equivalent (FPE)

Part 1 – Engineering in Context

Chapter 1: The place of engineering industry

Chapter 2: Contributions to UK economy and employment

Chapter 3: Demographics

Chapter 7: Higher education

Part 3 – Engineering in Employment

Chapter 8: Graduate destinations and recruitment

Part 1 – Engineering in Context
1 The importance of the engineering industry

Key points

Sector strengths

Engineering plays a vital role in the UK's economic and societal wellbeing, providing large-scale employment and the majority of the UK's physical exports, as well as implementing solutions to many global challenges.

The UK engineering base has a world-leading position in a variety of the knowledge-intensive industrial sub-sectors responding to these challenges, as well as in the scientific and technological research and innovation that underpin them.

Manufacturing remains one of the UK's largest economic sectors, despite automation having reduced its employment footprint. It requires continued investment in innovation to consolidate the development of advanced manufacturing technology and concepts such as Manufacturing 4.0.

Employment and productivity

Productivity growth, which is a determinant of higher wages and improved sustainable output, has been relatively weak since the recession, and lower than that of key comparator nations. Unless this situation is improved, it will hold back future growth in the economy.

Technological innovation and investment in upskilling the labour force are thought to be crucial to enhance productivity in engineering and manufacturing and in responding to the progressive re-shaping of the economy.

Engineering and related industries will require a higher proportion of more highly skilled labour in future, as automation and technology reduce the need for those with lower skills. This trend is already reflected in employers' reports of skills shortages and our own projections that the supply of level 4+ skills will not meet demand.

Industrial strategy

The engineering community is encouraged by the current government's early announcements of a developing industrial strategy. Government has intimated that there will be a significant 'horizontal' element to such a strategy: underpinning investments to assure increasing levels of skills, improving infrastructure, empowering science and research and embedding innovation. The engineering community endorses this approach to complement a 'vertical' strategy to support particular sectors or technologies. The need for a coherent, holistic industrial strategy is highlighted by the EU referendum result.

Leaving the EU

The result of the referendum has added uncertainty to predictions about the future shape and health of an export-led sector like engineering.

Equally important are the potential ramifications that leaving the EU could have on the future supply and development of high level skills for the engineering workforce. The engineering and ICT sectors are particularly dependent on inward migration of labour as the supply of skills from within the UK is insufficient.

Any resultant reductions to the inward migration of skills, either through higher education as international students or through international mobility of skilled employees, would impact engineering particularly adversely. Plans to prevent or offset such reductions would be a welcome element of a sound industrial strategy.

1.1 Introduction

Engineering is essential to the UK economy. In Chapter 2, we show that the sector contributed an estimated £486 billion to the Gross Domestic Product (GDP) of the UK in 2015 – equivalent to 26% of total UK GDP. This economic contribution is expected to increase further. If we add positive multiplier impacts, it has been estimated that:

- Every £1 in Gross Value Added (GVA) that engineering contributes to the UK economy goes on to generate a further £1.45 elsewhere in the economy;
- For every new engineering vacancy filled, a further 1.7 new jobs can be expected to be created throughout the UK economy;
- In 2015, engineering directly provided around 5.7 million jobs and supported over 10 million more in employment in the UK.[1.1]

The engineering sector produces most of the UK's physical exports. It supports the UK's international competitiveness through investment in research and development and innovation. In other words, it helps fuel the UK's long-term economic performance. Engineering can and should play a major role in the UK's re-emerging industrial strategy for achieving sustainable economic growth. This is desirable if we want to achieve, in the Prime Minister's words, an economy "that works for everyone".[1.2]

1.2 Growth factors: employment and productivity

The UK's economic performance is a long-standing – and, to some, concerning – point of discussion. Since the UK voted to leave the European Union in the 2016 referendum, theories have been rife on how existing challenges will be further complicated by the decision – although the extent of the impact won't be known for some time.

1.1 Analysis by Cebr for Engineering UK **1.2** BBC: *Teresa May chairs cabinet committee on economy*, August 2016 http://www.bbc.co.uk/news/uk-politics-36951890

In the years since the recession of 2008-2009 technically ended, wages and living standards have largely stagnated in the UK. Recent years have seen a substantial increase in the number of people employed and a decline in unemployment. However, productivity – how much is produced for a given input, such as an hour's work – has stagnated since 2008, and the UK is currently working slightly harder than it did in 2007 to produce the same amount of goods and services. The growth in GDP that has been achieved has largely been due to more hours being worked, rather than through higher productivity.

Why productivity growth is important

Productivity growth – commonly defined as rising output per worker, or output per hour worked – is essential for long-term increases in living standards. The more productive an economy is, the more that can be produced in a sustainable fashion. In other words, higher productivity growth leads to a higher long-term growth rate of the economy. Economic theory states that labour productivity – the value of output per hour worked – also determines wages: the more productive an employee is, the more they are likely to be paid. Productivity growth is therefore necessary for sustainable improvements in living standards and wages.[1.3]

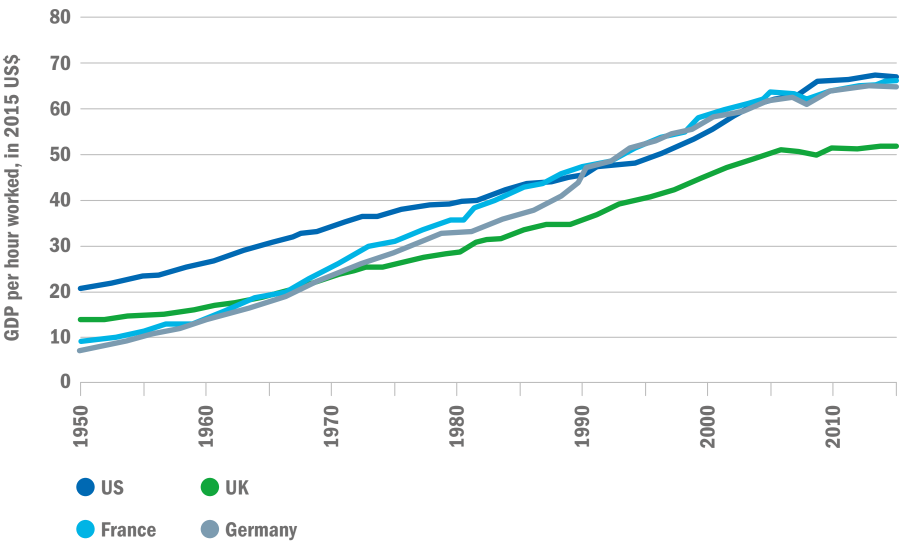
1.2.1 The UK's productivity record

Historically, UK labour productivity has grown by around 2% per year. However, the level of labour productivity during the second quarter of 2016 was only 0.1% above the same quarter eight years ago (which was the pre-recession peak). This is of concern to the government because strong productivity growth leads to stronger GDP growth, higher tax revenues and a lower budget deficit. Worryingly, the UK's stagnating productivity contrasts with trends in major competitor countries (Figure 1.1).

Estimates for 2015 show that, based on GDP per hour worked, the UK ranked equal fifth of the G7 countries (alongside Canada) in 2015 – well below the G7 average (Figure 1.2). Germany and the USA were at the top.

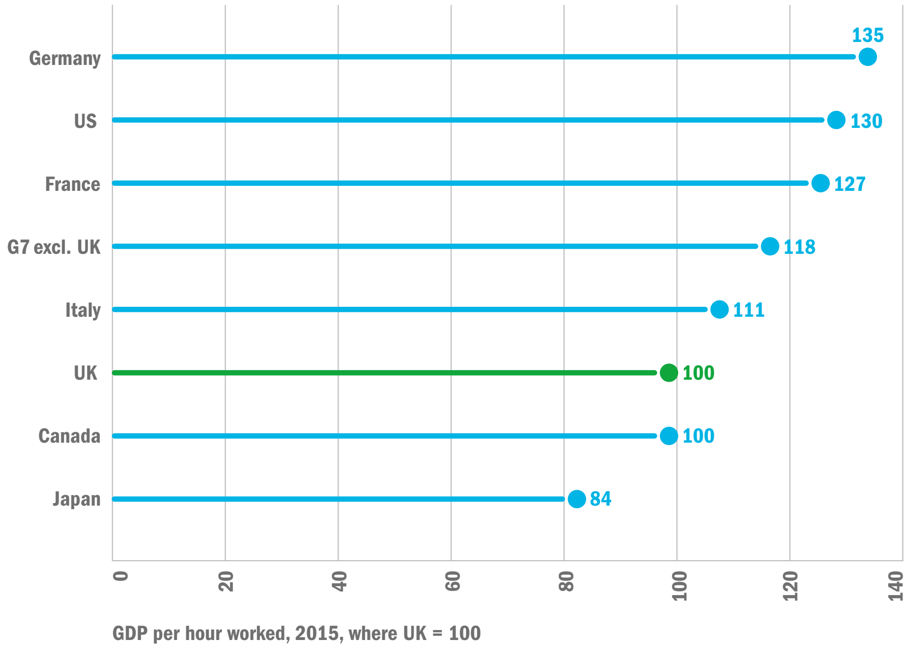
Based on the UK's strong productivity growth up to 2007, and weak productivity performance since then, the productivity gap in 2015 was around 18% (the same as in 2014). Put another way, had UK productivity continued to grow at its pre-downturn rate since 2007, the output per hour in 2015 would have been around 18% higher than it actually was. This was the largest productivity gap since the Office for National Statistics (ONS) began compiling data of this kind. Since 2007, Italy is the only other G7 nation that has seen weaker productivity growth than the UK.

Figure 1.1: Comparison of productivity (GDP per hour worked, in 2015 US dollars) in USA, Germany, France and UK since 1950[1.4]



Source: The Conference Board, Total Economy Database

Figure 1.2: 2015 gross domestic product per hour worked, for G7 nations, where UK = 100[1.5]



Source: ONS

1.3 House of Commons: *Productivity in the UK*. House of Commons Library Briefing Paper 06492, September 2016. http://researchbriefings.parliament.uk/ResearchBriefing/Summary/SN06492
1.4 The Conference Board: *Total economy database – Output, Labor, and Labor Productivity, 1950-2016*, May 2016. https://www.conference-board.org/data/economydatabase/index.cfm?id=27762
1.5 ONS: *International comparisons of UK productivity (ICP), first estimates: 2015*, October 2016. https://www.ons.gov.uk/economy/economicoutputandproductivity/productivitymeasures/bulletins/internationalcomparisonsofproductivityfirstestimates/2015

Back to Contents

1.2.2 Solving the 'productivity puzzle'

The rather persistent weakness in the UK's productivity has puzzled economists and many alternative theories have been put forward to explain it, including that:

- Productivity in the oil and gas and financial sectors has fallen;
- Weakness in investment has reduced the quality of equipment that employees work with;
- The banking crisis has led to a lack of lending to more productive firms;
- Employees within enterprises have been moved to less productive roles, not more;
- Rates of innovation and discovery have slowed down;
- The population is ageing;
- There are inaccuracies in the data.

A relatively detailed discussion of the 'productivity puzzle' was presented in last year's edition of this publication.[1.6] No single theory provides a sufficient explanation, which makes it difficult to predict when – and if – the UK's weakness in productivity growth will come to an end. What can be concluded, however, is that with the proportion of people in work at an historic high, only limited economic growth can be achieved by simply recruiting more people. For growth to continue at its recent pace of around 2% per year, the productivity of existing employees needs to be improved.

Some economists have called for job creation to be shifted towards the higher productivity sectors, encouraging firms to invest more in boosting workforce productivity. Others suggest spending on innovation and investment in productivity should be part of a national industrial strategy and it is in the recent green paper.[1.7] There are also calls to improve vocational and technical education and training, emphasising the need to upskill the existing workforce, not just training new entrants such as apprentices and graduates.[1.8]

In 2015, the government published a productivity plan.[1.9] It aims to improve the UK's transport and digital infrastructure, increase investment in the economy, enhance the skills of the workforce, build more houses, move people off welfare and into work, encourage exports and re-balance the economy away from its existing focus on London. More recently, Prime Minister Theresa May's government has been promoting its intention to develop a new industrial strategy, productivity growth in the green paper is prominent. This is surely welcome

in the engineering sector, which has the potential to be at the heart of productivity growth. Set against this, economic theory and academic literature show a link between an economy's degree of openness to foreign trade and investment and its productive capacity.[1.10] So there are also widespread concerns about the possible impact of the UK's impending departure from the European Union on long-term growth prospects.

1.3 The evolving UK economy and skills needs

1.3.1 The current structure of the economy

Although now two years old, Figure 1.3 is a useful snapshot of the UK economy in terms of the contributions of different industrial sectors to both UK Gross Value Added (GVA) and to total UK employment (information that, until 2015, was provided in the government's "growth dashboard").[1.11] The snapshot demonstrates how far the UK has shifted towards a service-dominated economy, in particular, knowledge-intensive services including professional and business services, and financial services. Together, these account for 34% of UK output and 29% of total employment.

In total, over three quarters of the UK GVA (77%) is provided by the service sector. The remainder is accounted for by manufacturing (10%), construction (7%), other production (5%) and agriculture (1%).

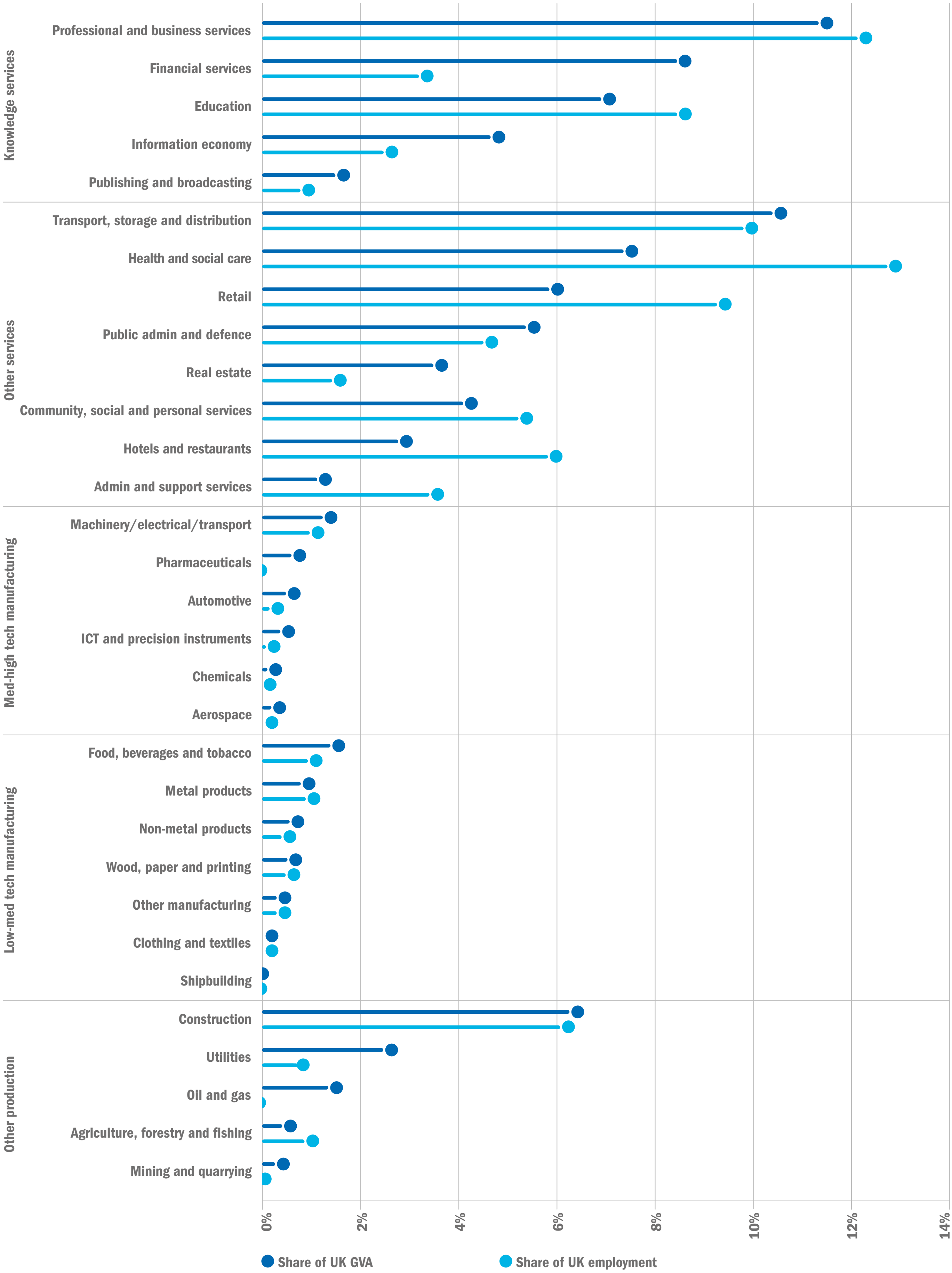
Services also dominate UK employment, accounting for 83% of jobs. Manufacturing (8%) and construction (6%) are the two next largest sectors in terms of employment size. Amongst the service sectors, health and social work (13%) is the largest sub-sector.

The profile of the UK's economy in terms of the number of enterprises of different sizes is also important to understand, and is treated in some detail in Chapter 2. In 2016, there were around 5.4 million SMEs (small and medium sized enterprises, which means any business with fewer than 250 employees): this was 99% of all UK businesses. Most of these are micro-businesses which have fewer than 10 employees. However, these only account for 32% of employment and 19% of turnover. Large enterprises, with more than 250 employees, accounted for only 0.1% of businesses but 40% of employment and 53% of turnover.[1.12]

In terms of size, the UK's mid-sized businesses (enterprises with a revenue between £10 million and £300 million) have proved to be a thriving area of the economy, surpassing FTSE 100 companies in many key areas of performance, including much greater growth in the number of jobs.[1.13] The UK's middle tier in terms of size employs 50% more people than it did in 2010 (up to 6.1 million jobs in 2014/15) and accounts for nearly a third of all private sector turnover. These mid-sized firms are agile enough to adapt to the new economic demands and big enough to take advantage of the opportunities offered by global growth, but too small to achieve the levels of attention that FTSE firms

1.6 EngineeringUK: *The state of engineering 2016*, December 2015. http://www.engineeringuk.com/Research **1.7** IPPR: *The missing pieces solving Britain's productivity puzzle*, August 2015. http://www.ippr.org/publications/the-missing-pieces-solving-the-uks-productivity-puzzle: HM government: *Building our Industrial Strategy* (green paper), January 2017. https://beisgovuk.citizenspace.com/strategy/industrial-strategy/ **1.8** CIPD: *Productivity plan fatally undermined by weak skills strategy*, July 2015. http://www2.cipd.co.uk/pressoffice/press-releases/productivity-plan-100715.aspx **1.9** HM Treasury: *Fixing the foundations: Creating a more prosperous nation*, July 2015. https://www.gov.uk/government/publications/fixing-the-foundations-creating-a-more-prosperous-nation **1.10** House of Commons: *Productivity in the UK*. House of Commons Library Briefing Paper 06492, September 2016. http://researchbriefings.parliament.uk/ResearchBriefing/Summary/SN06492 **1.11** https://www.gov.uk/government/publications/growth-dashboard **1.12** House of Commons Library: *Business statistics*, Briefing Paper 06152, October 2016. http://researchbriefings.files.parliament.uk/documents/SN06152/SN06152.pdf **1.13** BDO: *'Overlooked' mid-market firms essential to UK economic recovery*, 26 October 2015. https://www.bdo.co.uk/en-gb/news/2015/overlooked-mid-market-firms-essential-to-uk-econ?feed=1

Figure 1.3: Structure of the UK economy (2014)



Source: BIS

command from the media and policymakers. They are too large to benefit from policies specifically tailored to small businesses.

The UK economic and employment landscape is further complicated by strong variations across the home nations and different English regions. Much more detail of how the different regions and nations contribute to the UK economy and to total UK employment, and the extent to which engineering provides these contributions, is given in Chapter 2.

1.3.2 Upskilling in the labour market

In Chapter 10, we consider current trends in the UK labour market and make projections for the future demand and supply of skills.

The broader international labour market landscape shows an underlying trend towards what is recognised as the 'hourglass economy' (also discussed in Chapter 10). This predicts that there will be increasing demands for labour which is highly skilled, due to technological advances in the economy and the growth of knowledge-intensive services. Equally, it predicts greater demand for lower-skilled jobs in sectors such as health and social care to support our ageing population, and services targeted towards an increasing post-retirement population.

These areas of increase are at the expense of the 'squeezed middle' level of skills. The semi-routine nature of many middle-skilled occupations makes them especially vulnerable to automation, whereas many occupations that are traditionally low-skilled in terms of qualifications rely on other types of skill that are not readily automated. The prevailing predictions, particularly for economically developed nations, are for faster growth of higher- and lower-skilled jobs compared with middle-skilled jobs. This trend is expected to hold for the UK well into the next decade.

There is evidence that this hollowing out of the middle of the workforce, and increased demand for those towards both the top and lower rungs of the skills ladder, is already happening. In the two decades to 2014, the number of high-skilled jobs in the UK has risen by 2.3 million and, in some occupations, employers are routinely reporting that they are struggling to fill positions.[1.14] Demand for low-skill roles has also grown, with 1.8 million more jobs in areas such as care, administration and leisure. Consistently, employers in sectors like agriculture, and especially in health and social care, are having to rely on imported labour. Over the same 20-year period, there has been a significant decrease in the demand for middle-level skilled workers, with 1.2 million fewer jobs available for these largely 'routine' occupations.

Results from the *CBI/Pearson Education and Skills Survey* in 2016, summarised in Chapter 11, reflect precisely the situation in relation to skills levels: employers in many key sectors are becoming less and less confident about how they will fill their future needs for highly skilled labour, in comparison with being much more confident about recruitment at intermediate and lower levels.[1.15] This is by no means a uniquely UK phenomenon – it is being experienced in many economically-developed nations.

At a time when new technology is changing industries and automation impacting on occupations, it is important not to neglect some broad observations:

1. The value of employed human capital in the UK was estimated at £17.6 trillion in 2013, which was two and a half times the value of assets such as buildings, vehicles and machinery;[1.16]
2. Up to 90% of the current workforce will still be in work in the next decade. Tackling productivity deficits for the economy as a whole must therefore be based on issues around job design, technology and progression for those who are already in work. It cannot rely on new entrants who have acquired the latest skills through education;[1.17]
3. There are significant portions of the existing workforce whose skills are currently underused by their employers. Employers themselves reported that over two million workers were in this position in 2015.[1.18]

This presents the unambiguous conclusion that there is a need to up-skill significant segments of the current UK workforce and better prepare those who will enter it in future.

The UK Commission for Employment and Skills (UKCES) has recorded the progress already made in increasing the skill level of the UK workforce, as well as projecting needs for the next few years. Table 1.1 shows that over the decade 2002-2012, the number of individuals aged 19- to 64-years-old with skills at level 4 and above rose by more than 5 million (a rise of 11 percentage points), while the number with skills below level 2 fell by more than 3 million.[1.19] This took place against a population increase for this age group of nearly 3 million. It should also be pointed out that these data reflect the qualifications held by the individuals, not the skill levels that are actually required by their occupations (so underuse of skills could occur in the workforce).

The projections by UKCES for 2012 to 2020 are set out in Table 1.2. These suggest that the proportion qualified to level 4+ will increase from 37% to nearly 47% over this period. In fact, it is the segments with the highest level qualifications (levels 7 and 8) that are projected to grow fastest proportionally, although they obviously remain a small minority of the adult population.

The largest fall, on the other hand, is projected to be in those with no qualifications (a reduction in share of 3.7 percentage points, or a fall of 40% compared with the 2012 value). It is this group that drives much of the 6.2 percentage point fall amongst everyone below level 2. These

Table 1.1: Qualifications held by UK 19- to 64-year-olds (2002-2012)[1.20]

	2002		2012		2002-2012 change	
	%	Number	%	Number	Percentage point	Number
Level 7-8	4.7%	1,662,000	8.3%	3,190,000	3.7	1,528,000
Level 4-6	21.0%	7,490,000	28.8%	11,024,000	7.7	3,533,000
Level 4+	**25.7%**	**9,152,000**	**37.1%**	**14,214,000**	**11.4**	**5,061,000**
Level 3	19.2%	6,835,000	19.4%	7,446,000	0.2	610,000
Level 2	20.3%	7,217,000	19.7%	7,534,000	-0.6	316,000
Level <2	**34.8%**	**12,394,000**	**23.9%**	**9,144,000**	**-11.0**	**-3,250,000**
Level 1	19.0%	6,775,000	14.7%	5,627,000	-4.4	-1,148,000
No qualifications	15.8%	5,619,000	9.2%	3,516,000	-6.6	-2,102,000
All qualifications	**100.0%**	**35,599,000**	**100.0%**	**38,337,000**	**0.0**	**2,738,000**

Source: UKCES

1.14 Policy Network: *Owning the future, how Britain can make it in a fast-changing word*, August 2014. http://www.policy-network.net/publications/4712/Owning-the-Future **1.15** CBI: *The right combination – CBI/Pearson education and skills survey 2016*, July 2016. http://www.cbi.org.uk/cbi-prod/assets/File/pdf/cbi-education-and-skills-survey2016.pdf **1.16** Office for National Statistics: *Human Capital Estimates*, 2014. http://www.ons.gov.uk/peoplepopulationandcommunity/wellbeing/articles/humancapitalestimates/2015-08-25 **1.17** UKCES: *Growth through people*, November 2014. https://www.gov.uk/government/publications/growth-through-people-a-statement-on-skills-in-the-uk **1.18** UKCES: *Employer Skills Survey 2015 – UK results*, May 2016. https://www.gov.uk/government/publications/ukces-employer-skills-survey-2015-uk-report **1.19** UKCES: *UK Skill Levels and International Competitiveness 2013*, Evidence Report 85, August 2014, p4. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/349939/140829_skill_supply_projections_final_bound.pdf **1.20** Note that 'no qualifications' are individuals below level 1, but could include those with entry level qualifications.

Table 1.2: Projected distribution of qualifications held by UK 19- to 64-year-olds (2002-2012)[1.20]

	2012		2020		2012-2020 change	
	%	Number	%	Number	Percentage point	Number
Level 7-8	8.3%	3,190,000	11.4%	4,483,000	3.0	1,293,000
Level 4-6	28.8%	11,024,000	35.3%	13,933,000	6.6	2,910,000
Level 4+	**37.1%**	**14,214,000**	**46.7%**	**18,416,000**	**9.6**	**4,202,000**
Level 3	19.4%	7,446,000	17.5%	6,884,000	-2.0	-562,000
Level 2	19.7%	7,534,000	18.2%	7,164,000	-1.5	-369,000
Level <2	**23.9%**	**9,144,000**	**17.7%**	**6,980,000**	**-6.2**	**-2,163,000**
Level 1	14.7%	5,627,000	12.1%	4,767,000	-2.6	-861,000
No qualifications	9.2%	3,516,000	5.6%	2,214,000	-3.7	-1,303,000
All qualifications	**100%**	**38,337,000**	**100%**	**39,445,000**	**0**	**1,108,000**

Source: UKCES

projections suggest that there will be almost 1 million fewer people with intermediate level skills between 2012 and 2020.[1.21]

1.3.3 Future UK skills shortages

UKCES, with support from the Institute for Employment Research at the University of Warwick, looked at the shape of the UK's economic activity and employment in 2014-15 in its *Working Futures* report. The report suggests that private sector services will be the main component of employment growth, with the strongest growth in professional services and information technology.[1.22] Manufacturing is expected to decline in terms of its scale of employment, but it will become more skilled as a sector as it becomes more automated and its productivity rises. Construction, long a volatile sector, is expected to grow again, with investments in infrastructure as well as house building in response to our rising population.

Translating these projections into expected requirements for labour and skills, UKCES anticipates that the polarisation of the workforce (towards the hourglass shape) will occur but with a bias towards higher skills occupations. It predicts that 54% of all jobs will be held by people with level 4+ skills by 2024. Growth of up to two million jobs is expected for managers, professionals and associate professionals, particularly in professional services, ICT, and manufacturing. At the same time, more than 400,000 additional jobs are expected in caring, leisure and other service roles.

A further particular cause for concern is technician-level skills. By 2020, the UK is set to fall to 28th out of 33 OECD countries in terms of developing intermediate-level technical skills, and these skills are not currently well served by the education system.[1.23]

EngineeringUK's bespoke projections for engineering-related occupations are described in detail in Chapter 10. These show sizeable replacement demand (not least from a slightly older workforce than the average for all sectors) as well as strong expansion demand from key sectors such as ICT and construction.

This is the backdrop to the picture experienced on the ground by employers. Comparing the results of the Employer Skills Surveys in 2013 and 2015, there was a 43% rise in the number of Skill Shortage Vacancies reported, with nearly 20% of employers reporting that they had at least one current vacancy.[1.24] This density of Skill Shortage Vacancies (the proportion of vacancies that are hard to fill because of a lack of skills) has remained steady in England and Scotland, despite the total number of vacancies rising, but increased in Wales.

The highest densities of Skills Shortage Vacancies in engineering-related sectors are among some of the skilled trades, as well as among science, research, engineering and technology professionals (Figure 1.4).[1.25] These vacancies were caused because of a lack of people with the necessary technical and practical skills (such as operational and analytical capability) or qualifications, and also the required personal attributes (such as management capability or customer-related skills). Very similar shortages of scientific and engineering-related professionals are also being experienced throughout Europe.[1.26]

Increasingly, there are signs that the combination of technical skills – often evidenced through qualifications – and a good range of key personal or 'transferable' skills determine a candidate's employability in the eyes of the employer. It has been suggested that over half a million UK workers will be significantly held back by deficits in these types of personal skills (sometimes referred to as 'soft' skills) by 2020, right across the economy.[1.27]

The need for a better mix of technical and transferable skills has been highlighted in recent reviews of the transition of STEM and computing graduates into the labour market. It has been suggested that employers need to help universities more in terms of building both types of skills, and potentially that development of employability in this way should become part of the accreditation of higher education courses.[1.28, 1.29]

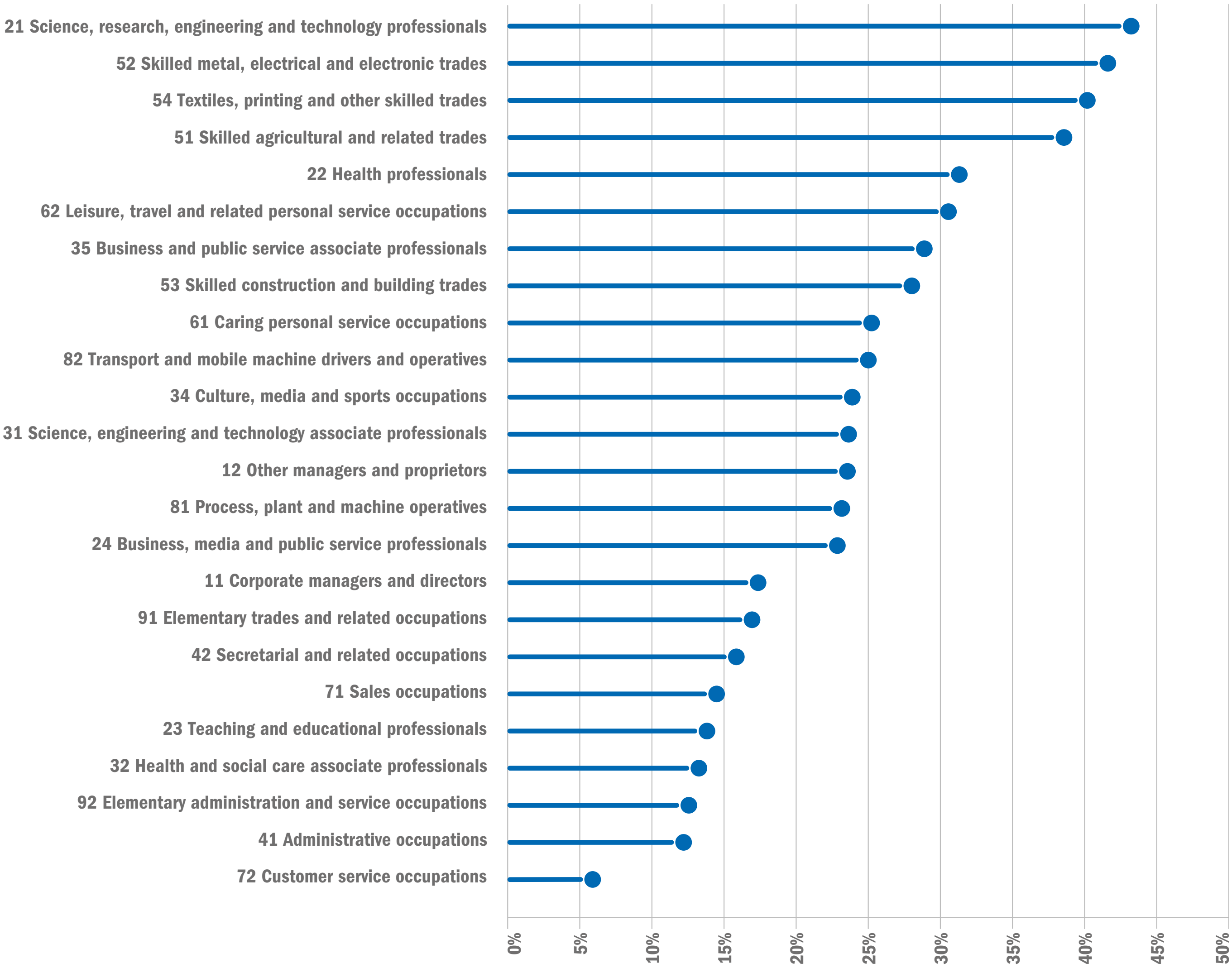
In Chapter 10, we consider how the currently expected supply of skilled entrants to the engineering workforce will meet the projected requirements for skills, at least in terms of the number of people at different skill levels. The model predicts a shortfall, as has been the case for several years. This fuels the case for sustained effort to increase the number of young people eligible through their education to choose and enter employment in engineering-related sectors and occupations, and who chose to do so. It also poses questions for the engineering community about how skilled people can be retained in the workforce throughout their careers, as well as how inter-sector or international mobility of labour could help to meet the shortfall.

The ramifications of the UK's decision to leave the EU are very significant in this context, and add large uncertainties to projections of both demand for and supply of skills. The demand side will be affected by the evolving balance and extent of exports. This will depend on both on the UK's position in markets, the value of sterling, and any impacts from reduced inward investment. The supply side could be impacted by the quantity of skilled people emerging from the qualification system (particularly in relation to the number and range of international students), as well as the inward mobility of labour (for example, a lower value of sterling potentially making employment in the UK unattractive for mobile workers).

These matters are discussed more in Section 1.8.

1.21 UKCES: *ibid* **1.22** UKCES: *Working Futures 2014-2024*. https://www.gov.uk/government/publications/uk-labour-market-projections-2014-to-2024 **1.23** DfE and BIS: *Report of the independent panel on technical education*, July 2016. https://www.gov.uk/government/publications/post-16-skills-plan-and-independent-report-on-technical-education **1.24** UKCES: *Employer Skills Survey 2015*. https://www.gov.uk/government/collections/ukces-employer-skills-survey-2015 **1.25** UKCES: *Employer Skills Survey 2013*. https://www.gov.uk/government/collections/ukces-employer-skills-survey-2013 **1.26** European Parliament: *Labour Market Shortages in the European Union*, 2015. http://www.europarl.europa.eu/RegData/etudes/STUD/2015/542202/IPOL_STU(2015)542202_EN.pdf **1.27** Development Economics: *The Value of Soft Skills to the UK Economy*, January 2015. http://backingsoftskills.co.uk/The%20Value%20of%20Soft%20Skills%20to%20the%20UK%20Economy.pdf **1.28** BIS: *Wakeham Review of STEM Degree Provision and Graduate Employability*, May 2016. https://www.gov.uk/government/publications/stem-degree-provision-and-graduate-employability-wakeham-review **1.29** BIS: *Computer science degree accreditation and graduate employability: Shadbolt review*, May 2016. https://www.gov.uk/government/publications/computer-science-degree-accreditation-and-graduate-employability-shadbolt-review

Figure 1.4: Density of skills shortages by occupational grouping (SOC 2010 sub-major group) (2013)



Source: UKCES

1.4 Sector strengths and opportunities

This section aims to provide a brief reminder of some nascent and established engineering sub-sectors where the UK has proven strength and potential capability to provide enhanced productivity and the highly-skilled employment that the economy needs.

Automotive

The UK produced 900,000 new cars in the first half of 2016, which was the highest number for that period since 2000. The annual production of nearly 1.6 million vehicles in 2015 generated over £71 billion turnover and exports of £34 billion, which was nearly 12% of all the UK's exports.[1.30] Of these, 77% were built for export: 57% into the EU. The sector employs 814,000 people: 169,000 of them directly in manufacturing (5.9% of the UK's manufacturing jobs). It expects to need 50,000 more by 2020. In 2015, it is estimated that £2.25 billion was invested in research and development (R&D). Connected and autonomous vehicles are a key focus for the future. This area is expected to provide over 300,000 additional jobs by 2013, including 25,000 in advanced manufacturing.

Aerospace and space

The UK is Europe's largest aerospace cluster and manufacturer, and second only to the United States globally. UK firms produce some of the most advanced and valuable elements of today's aircraft, with strengths in design and manufacture of engines, wings, aerostructures and avionics systems. However, the number of direct employees is falling. It is currently at around 128,000, with 26,000 in research, design and engineering, and more than 50,000 in its supply chains. Productivity has grown by 39% since 2010. It creates annual revenues of over £31 billion, of which nearly 90% is from exports. The civilian segment of the market is driving growth, while the defence segment is also growing slightly.[1.31]

Aerospace is a highly R&D-intensive industry. It enjoys strong support from the government and accounts for over 10% of all R&D investment in UK manufacturing. A new strategy was launched in 2016 which highlighted the potential to generate US $5.5 trillion in sales over the next 20 years of greener, quieter and more economical aircraft. The strategy aims to steer investment in the skills that will be needed to achieve that potential, including new master's courses and apprenticeships.[1.32]

1.30 SMMT: *Motor industry facts 2016*, http://www.smmt.co.uk/wp-content/uploads/sites/2/SMMT-Motor-Industry-Facts-2016_v2.pdf **1.31** ADS: *Facts and figures 2016.* https://www.adsgroup.org.uk/facts2016/ **1.32** BEIS: *Means of ascent: strategy for UK aerospace 2016*, July 2016

Recent government industrial policy announcements are increasingly also mentioning space – a sub-sector that has featured quite strongly in previous government investments.[1.33] This suggests that the UK has a goal of increasing its share of the expected £400 billion global space-enabled market to 10% by 2030, and potentially growing the UK space industry to £19 billion turnover by 2020.

Agricultural technologies (Agri-tech)

Agricultural science and technology is globally a fast-growing market, driven by population growth and the development aspirations of emerging economies, as well as geopolitical instabilities around shortages of land, water and energy. Technology advance is underpinning much of this industry, in genetics, nutrition, informatics, satellite remote sensing, precision farming and low-impact agriculture. As such, it is heavily dependent on strong scientific capability. Since 2013, the government has had a long-term agri-tech strategy in place, in partnership with industry, to ensure the knowledge and insight from the UK's world-leading science base are translated into benefits for society and the economy.[1.34] A continuing strong scientific capability is required to support the supply chain for the agri-tech sector, which makes an estimated contribution of £96 billion or 7% of gross value added (GVA) to the UK and employs 3.8 million people.[1.35]

'Big data'

Big data refers to the handling of information and datasets that are so large, dynamic and complex that traditional techniques are insufficient to analyse their content. In 2012, it was one of the 'eight great technologies'[1.36] identified by the government to support UK science strengths and business capabilities. A massive global market for data analysis products and services is anticipated. A UK strategy was articulated in 2013.[1.37] This will be incorporated in the forthcoming UK Digital Strategy, to enable the UK to capitalise on its world-leading data capabilities, and the public sector to develop the sustainable solutions promised by big data within a secure regulatory and practical framework. The government also needs to urgently address the current digital skills shortage, by supporting the development of 'data analytics' skills — a mix of technical skills, analytical and industry knowledge, and the business sense and soft skills to turn data into useful information and intelligence.[1.38]

Another aspect of this debate is how to address valid privacy and security concerns at the same time as obtaining the benefits of sharing data.

Construction

The construction sector contributes over 6% of the UK's total GVA and 6.5% of the total UK workforce (as shown in Figure 1.3). Together with construction-related services, products and materials, and its large supply chain, the sector contributes nearly 7% of UK GVA and supports over 9% of all employment. In 2016, the government released a new National Infrastructure Delivery Plan which collates its plans for economic infrastructure through to 2021 together with those to support delivery of housing and social infrastructure. The plan includes a commitment to invest over £100 billion, alongside significant private sector investment,[1.39] to support growth and create jobs in the short term as projects are built. In the longer term, the aim is to raise the productive capacity of the economy by harnessing the benefits of the new infrastructure, and finding synergies and opportunities for integration of projects small and large (including HS2, Crossrail, Hinkley Point C, the expansion of Heathrow) that could reap further benefits.

Despite its size, and role as something of a bellwether of overall economic health, the sector has problems with productivity. In the US as well as the UK, this has scarcely improved in 20 years. In fact, it has fallen behind productivity growth in many other sectors. In construction, labour is still the dominant determinant of overall productivity, whereas in other industries, automation has increased effectiveness. It has been observed that upturns in UK construction productivity occur during economic slowdowns. This is because higher activity demands a bigger workforce, resulting in businesses taking on less productive workers. These workers dilute its overall productivity, but then exit the workforce during the slowdowns. The Farmer Review is the latest of many inputs that attempt to reform the industry in a bid to reduce its vulnerability to skills shortages.[1.40] The review points to underinvestment in training and development and a lack of innovation preventing a rise in productivity. It concludes that workforce attrition, exacerbated by an ageing workforce, means that there is now a fundamental imperative for change. It also challenges the sector to do things differently, and to innovate in order to reduce the reliance on traditional building methods with their heavy demand for on-site labour.

Creative digital

Digital technology has transformed and re-energised parts of the creative economy, resulting in it growing its exports by 11% in 2015. Depending on the definition used, the creative industries contribute £84 billion to the economy and employ 9% of the UK's workforce.[1.41] Within this larger picture, the creative digital sector encompasses a wide range of activities including digital media publishing and advertising, computer games, film and music, creative arts and entertainment. Digital technology has revolutionised the range of job roles involved, and introduced requirements for a range of STEM skills into what was archetypically the 'arts'. The UK is a world leader in areas such as post-production special effects in films, games design and digital advertising.

Life sciences

The life science industry, which covers medical devices, medical diagnostics and pharmaceuticals, through to synthetic and industrial biotechnology, is seen by many as a jewel in the crown of the UK economy and is a fundamental part of its growth strategy.[1.42] The government's *Strategy for UK Life Sciences*[1.43] dates from December 2011, when it also launched an Office for Life Sciences. The strategy set out a range of specific measures from the Department for Business, Innovation & Skills and the Department of Health to help the UK develop an 'integrated healthcare economy' to accelerate medical innovation. The various measures covered five key areas including translational research infrastructure; venture investment; industrial inward investment; NHS adoption of innovation; and international promotion of the UK's position.[1.44]

The sector includes some 380 pharmaceutical companies based in the UK, employing nearly 70,000 people, with an annual turnover of over £30 billion. While pharmaceutical manufacturing continues to an extent in the UK, research and development is the dominant activity. However, international pharmaceutical companies now offshore their development work on a truly global basis. The medical technology and biotechnology sectors together employ another 100,000 people in the UK, with a turnover of around £20 billion.

1.33 BIS: Space innovation & growth strategy 2014-2030 *Space Growth Action Plan,* April 2014. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/298362/igs-action-plan.pdf **1.34** HM government: *Agricultural technologies (agritech) strategy*, https://www.gov.uk/government/collections/agricultural-technologies-agri-tech-strategy **1.35** *Reviewing the requirement for high level STEM, UKCES skills, Evidence Report 94*, July 2015, p32 https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/444052/stem_review_evidence_report_final.pdf **1.36** BIS: Eight great technologies (speech by David Willets Minister for Universities and Science), 2013: https://www.gov.uk/government/speeches/eight-great-technologies **1.37** HM government: *Seizing the data opportunity – a strategy for UK data capability*, https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/254136/bis-13-1250-strategy-for-uk-data-capability-v4.pdf **1.38** House of Commons Science and Technology Committee: *The big data dilemma*, February 2016. http://www.publications.parliament.uk/pa/cm201516/cmselect/cmsctech/468/468.pdf **1.39** Infrastructure and Projects Authority: *National Infrastructure Delivery Plan 2016–2021*, March 2016. http://kj06q2hv7031ix2143c36tpx.wpengine.netdna-cdn.com/wp-content/uploads/2016/03/2904569_NIDP_2016-2021_updated.pdf **1.40** Construction Leadership Council: *Modernise or die – The Farmer Review of the UK Construction Labour Model*, October 2016. http://www.constructionleadershipcouncil.co.uk/wp-content/uploads/2016/10/Farmer-Review.pdf **1.41** DCMS: *DCMS Sectors Economic Estimates*, August 2016. https://www.gov.uk/government/statistics/dcms-sectors-economic-estimates-2016 **1.42** UKCES: *Reviewing the requirement for high level STEM skills*, July 2015. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/444052/stem_review_evidence_report_final.pdf **1.43** BIS: *UK life sciences strategy*, December 2011 https://www.gov.uk/government/publications/uk-life-sciences-strategy **1.44** BIS: *UK life sciences strategy, one year on*. 2012 https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/36684/12-1346-strategy-for-uk-life-sciences-one-year-on.pdf

Low carbon economy including renewable energy

The low carbon economy is the umbrella term for activities that generate products or services that, in turn, deliver low-carbon outputs. These include energy and heat generation, waste processing, energy efficiency products, low-carbon vehicles and related services. The size and performance of these activities in the UK in 2013 were assessed at £122 billion turnover, supporting over 460,000 jobs, and growing strongly.[1.45] This is nearly double the value of the automotive manufacturing industry, much larger than the aerospace industry, and on level terms with the food and drink industry.

Global renewable energy generation capacity recently overtook that of coal, following massive investment worldwide, including in nations such as China. It now provides around a fifth of the UK's electricity needs, powering 15 million homes. Technologically, the UK leads the world in offshore wind, although none of the top ten companies in the market is British, while the UK is also a leader in marine energy.[1.46] Offshore wind has been increasing its contribution both to fulfilling energy needs and also to employment, and by 2020 could account for 7-12% of UK electricity generation. Onshore wind already provides over 5% of the UK's total electricity generation, but its ability to grow further has been stifled, according to some, by the Energy Bill in 2016, which tightened planning restrictions and reduced subsidies at a time when capacity development is rapidly cheapening.[1.47]

The growth of solar photovoltaic (PV) energy conversion capacity is evident in the UK's fields and on its rooftops. As of August 2016, overall UK solar PV capacity stood at over 11,000MW across nearly 900,000 installations. This was an increase of 30% from August 2015. Around half comes from larger-scale installations (5MW or more), which are ground-mounted or standalone solar installations.[1.48] In terms of employment, in 2013 the solar PV sector and supply chain were thought to provide over 34,000 jobs.[1.49]

The UK is ranked as the world's second most attractive place to invest in marine energy,[1.50] with theoretical potential for up to 27GW of wave power, 32GW of tidal stream power, 45GW from tidal barrages and a further 14GW from tidal lagoons in the UK. To date, this remains a relatively undeveloped renewables sector. Hydroelectricity, on the other hand, is a more mature part of the sector, which in 2013 supported 7,400 jobs and just under 2% of the UK's total electricity generation.[1.51] Biomass and bioenergy are a more substantial segment, providing 6% of generation and (in 2013) over 31,000 jobs.[1.52]

Meeting the UK's climate change commitments will be challenging if carbon capture and storage (CCS) technology is not fitted to new gas-fired power stations and to energy-intensive industries. Initially, this would require significant investment in infrastructure. The UK government launched a commercialisation competition in 2012 with the aim of seeing CCS projects by 2020, offering capital funding and operational support through guaranteed price contracts. However, at the end of 2015 it withdrew the investment fund. It is hoped that a new strategy for CCS will be implemented in the near future, potentially in conjunction with the National Infrastructure Commission.[1.53]

The coalition government also made a commitment to grasp the opportunities of electric, hydrogen-powered and other low-carbon vehicles. It offered a vision that by 2050, almost every car and van in the UK would be an ultra low emission vehicle (ULEV), and placing the UK at the forefront of their design, development and manufacture.[1.54]

Nuclear energy

The UK government's projection is that 95GW of new generating capacity will be needed and constructed by 2035, which is equivalent to 90% of the grid's current capacity.[1.55] This is based on a number of factors:

- a 20% increase in demand for electricity over the next two decades because of demographic changes, economic growth and the electrification of heat and transport;
- the UK's ageing coal and nuclear power stations, which provide nearly 30GW of capacity, closing as they reach the end of their technical lives;
- existing but inefficient generating sources being replaced with new capacity;
- an increasing proportion of generation coming from intermittent renewable sources such as wind and solar power which require some back-up capacity to ensure sufficient supply to meet demand.

It wants nuclear power to form an important part of a 'balanced mix' of generating technologies over the long term, to provide reliable, low carbon and cost competitive electricity. Between now and 2035, around 14GW of new nuclear generating capacity may be built. This would be a renaissance of the UK nuclear industry, as the last new nuclear power station in the UK was completed in 1995. In September 2016, the government approved a new £18 billion nuclear power station at Hinkley Point in Somerset, financed by the French and Chinese governments.

1.45 BIS: *The size and performance of the UK low carbon economy*, March 2015. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/416240/bis-15-206-size-and-performance-of-uk-low-carbon-economy.pdf **1.46** DECC: *Delivering UK Energy Investment: Low Carbon Energy*, March 2015 **1.47** Business Green: *Energy Bill approved after DECC wins wind farm battle.* http://www.businessgreen.com/bg/news/2457666/energy-bill-approved-after-decc-wins-wind-farm-battle **1.48** ONS: Solar voltaics deployment, September 2016. https://www.gov.uk/government/statistics/solar-photovoltaics-deployment **1.49** BIS, 2015, ibid. **1.50** EY: *Renewable Energy Country Attractiveness Index*, March 2015: http://www.ey.com/Publication/vwLUAssets/Renewable_Energy_Country_Attractiveness_Index_43/$FILE/RECAI%2043_March%202015.pdf **1.51** Energy Trends December 2014, https://www.gov.uk/government/statistics/energy-trends-december-2014 **1.52** DECC analysis based on BIS (March 2015): The Size and Performance of the Low Carbon Economy. https://www.gov.uk/government/publications/low-carbon-economy-size-and-performance and REA: Review (April 2014): http://www.r-e-a.net/resources/rea-publications. Includes power from biomass, waste and anaerobic digestion, and includes supply chain. **1.53** House of Commons Energy and Climate Change Committee: *Future of carbon capture and storage in the UK*, February 2016. http://www.publications.parliament.uk/pa/cm201516/cmselect/cmenergy/692/692.pdf **1.54** DfT: *Driving the Future Today A strategy for ultra low emission vehicles in the UK*, 2013. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/239317/ultra-low-emission-vehicle-strategy.pdf **1.55** NAO: *Nuclear power in the UK,* July 2016. https://www.nao.org.uk/wp-content/uploads/2016/07/Nuclear-power-in-the-UK.pdf

This is expected, together with the anticipated redevelopment of the UK's nuclear submarine capability, to drive an expansion of the nuclear workforce from 70,000 to 98,000 by 2021.[1.56] This will be challenging, as the UK's existing expertise lies primarily in the operation and decommissioning of nuclear plants, not their construction, so we need to reskill workers or attract new skills. Nuclear will have to compete with other sectors for workers without specialist nuclear skills, for construction, project management and technical roles, and to source talent from overseas. Highly skilled nuclear specialists will also be needed, but it typically takes 5-25 years to develop these skills. The government has the aspiration to meet 90% of these skill demands from within the UK, by developing the right profile and pipeline of skills to meet the future demands of the sector. The Nuclear Industry Council and National Skills Academy for Nuclear (NSAN) are working with employers within a 'Nuclear Energy Skills Alliance' to direct and develop the skills agenda. Attracting people to careers in nuclear, finding innovative ways to recruit and retain them, identifying potential skills gaps and stemming them, putting in place high quality professional development programmes, and maintaining high-level research skills will all be necessary. Nuclear is a microcosm of the challenges which the engineering sector faces.

Oil and gas

Oil and gas provide more than 70% of the UK's total primary energy and are expected to do so until at least 2030.[1.57] This is predominantly oil for transport and gas for heating, rather than for electricity generation (although gas provides 30% of the UK's electricity). Demand for oil and gas is growing, though slowing, but indigenous oil and gas production has fluctuated: after annual declines of 7-8% per year since its peak in 1999, the last two years have seen growth in production again. In total, 43 billion barrels of oil have been extracted since the first UK Continental Shelf production in 1967, resulting in payment of £330 billion in corporate taxes (although since 2014 production is operating at a loss due to the low price of oil). Turnover fell 10% in 2015 and is expected to be 20% lower still in 2016, falling below £30 billion for the year. Capital investment and expenditure have been reduced sharply in 2016 in response.

Across the UK, oil and gas supports around 330,000 jobs. Of these, around 34,000 are directly in the sector, 150,000 indirectly and 145,000 induced (that is, jobs that are created by the sector's spending in the wider economy). This is around 27% lower than peak employment in 2014. The fortunes of the oil and gas sector are closely wedded to the price of oil, and the sector seems certain to bounce back in future years, returning to its position as a key part of the UK engineering scene due to its heavy reliance on capital investment and costly infrastructure.

In the meantime, shale gas will soon become an indigenous source of energy supply in the UK, as the government has approved Cuadrilla's plans to explore for shale gas through fracking (hydraulic fracturing) in Lancashire.[1.58] Several business organisations believe that shale gas production could satisfy up to a third of the UK's annual gas demand by 2030 and could create many thousands of jobs, while reducing potential reliance on imported energy.[1.59]

Road and rail transport

Across the UK, the government anticipates investing over £400 billion in transport projects and programmes, from large schemes like Crossrail, HS2 and electrification, down to much needed road improvements. The organisations involved in transport and its development employ more than 300,000 people directly or indirectly; the road and rail infrastructure projects within the transport sector have a current labour demand for 160,000 in construction alone.[1.60] Interestingly, Crossrail indicates that 40% of its current workforce is from outside the UK. Around 115,000 people are employed in rail operations and maintenance, 58,000 in passenger and freight operations and 57,000 in infrastructure operations. A further 40,000 work on road maintenance and operations. Significant growth in freight and passenger traffic is expected, potentially doubling by 2030. Together, these developments require a major step-up in attracting the right people with the right skills to meet the challenges of new technology in transport. The government has committed to trebling the number of apprenticeships in the sector to 30,000, of which half will be at level 3+.

This is also a sector where the effect of disruptive technology may be strongly felt, such as the current high interest in autonomous vehicles. However, it is hard to predict how soon they will be introduced at any scale or how this could affect the future balance of employment.

Higher education

Universities and other providers of higher education play an intrinsic role in the UK economy. They increase skills through provision of teaching and learning, support innovation through research, and attract both investment and talent. UK higher education is a high-growth UK export industry in its own right. In its 2013 industrial strategy, the government estimated that higher education exports were worth over £17.5 billion to the UK economy[1.61] as part of its overall contribution to GDP of around £40 billion. Universities directly employ around 400,000 people and support as many more jobs in other sectors of the economy in their supply chains.[1.62]

Of particular relevance in this report is the contribution made by higher education in terms of STEM teaching, qualifications and research. Education exports in the STEM subjects are second only to business and management in terms of their value, and the proportion of international students on STEM courses on campuses in the UK is high in places, especially at postgraduate level. This export function of higher education not only brings in export revenue but attracts international talent, which is then deployed in providing the teaching, but also undertaking the research that supports the UK's innovative capacity in the STEM industries.

1.5 Manufacturing

Manufacturing continues to contribute over 10% of UK GVA: the ninth highest output in the world at $247 billion in 2014.[1.63] Some 2.7 million people are directly employed in the UK's manufacturing industries, and it is responsible for around half of the UK's exports.[1.64] The 2015/16 picture for manufacturing was mixed, ranging from the impact of the global collapse in demand for steel in terms of closures, retrenchment and downsizing, to other sub-sectors, such as aerospace and motor vehicles, reporting strong upwards sales. Lower oil prices have filtered through to lower product pricing, and something of a post-referendum temporary export boom is being experienced as the pound falls sharply. However, current challenges in world trade are expected to lead to major impact on manufacturing exports, including the anticipation that China will focus more on domestic production and less on imports. There is also uncertainty over future US trade policy direction, as well as the shape of the UK's future trading relationship with EU countries and others.

Over two-thirds of UK business investment in research and development is in manufacturing. The contribution of different sectors to that total varies considerably, as shown in Table 1.3.

1.56 DECC: *Sustaining Our Nuclear Skills*, 2015. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/415427/Sustaining_Our_Nuclear_Skills_FINAL.PDF **1.57** Oil and Gas UK: *Economic report 2016* http://www.oilandgasuk.cld.bz/Economic-Report-2016-Oil-Gas-UK/2 **1.58** BBC: *Fracking in Lancashire given go-ahead by government*, October 2016. http://www.bbc.co.uk/news/uk-england-lancashire-37567866 **1.59** Emily Gosdea: *Shale gas 'could be a new North Sea for Britain'*, Telegraph, 22 May 2013. http://www.telegraph.co.uk/finance/newsbysector/energy/10072029/Shale-gas-could-be-a-new-North-Sea-for-Britain.html **1.60** DfT: *Moving Britain ahead – Transport Infrastructure Skills Strategy: building sustainable skills,* 2016. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/495900/transport-infrastructure-strategy-building-sustainable-skills.pdf **1.61** BIS: *International Education: Global Growth and Prosperity*, July 2013. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/340600/bis-13-1081-international-education-global-growth-and-prosperity-revised.pdf **1.62** Universities UK: *The impact of universities on the UK economy*, 2014. http://www.universitiesuk.ac.uk/highereducation/Pages/ImpactOfUniversities.aspx **1.63** House of Commons Library: *Manufacturing – International Comparisons*, Briefing Paper Number 05809, August 2016. http://researchbriefings.parliament.uk/ResearchBriefing/Summary/SN05809 **1.64** EEF: *2016/17 UK Manufacturing Fact Card* https://www.eef.org.uk/campaigning/campaigns-and-issues/manufacturing-facts-and-figures

Manufacturing innovation, as indicated by investment in R&D, is driven by three broad sectors: chemicals and pharmaceuticals, transport, and electronics. The seven manufacturing sectors that spend the most on R&D accounted for 68% of the total UK business R&D expenditure in 2014. Pharmaceuticals continued to lead, despite experiencing decreasing expenditure for a third successive year. The largest increase was in the motor vehicles and parts group: up to £2.3 billion, an increase of 11% from 2013. R&D for computer programming and information services increased by 10%.[1.65] These figures are also considered in Section 1.6.2.

Table 1.3: UK Manufacturing sectors: share of total manufacturing GVA and manufacturing R&D expenditure (2014)[1.66]

Sector	Share of manufacturing GVA	Share of business R&D in manufacturing
Food and drink	17%	3%
Chemicals and pharmaceuticals	14%	35%
Rubber, plastics and non-metallic minerals	8%	1%
Metals	12%	2%
Electronics	5%	13%
Electrical equipment	3%	3%
Machinery	6%	7%
Transport	14%	33%
Other manufacturing	21%	3%

Source: ONS and EEF

1.5.1 Manufacturing competitiveness

In the UK's diverse manufacturing landscape, the competitive pressures on firms take multiple forms. Pressures from overseas competitors with lower labour and materials costs and greater agility – key factors in the decline of UK manufacturing in the latter part of the twentieth century – are well-known. This century, competitive edge has increasingly depended on factors such as scale and speed of automation, ability to commercialise new technologies, health of supply chains, and adoption of innovative business models as well as fiscal systems and finance.

One much-discussed challenge is the UK manufacturing supply chain, which is widely seen as 'hollowed out' to a dangerous degree following extensive offshoring of manufacturing over the last thirty years. However, as technology's importance in manufacturing grows, the cost of labour – the rationale for much of that offshoring – becomes an ever smaller proportion of the cost of manufacturing activity. Labour cost diminishes as a driver of manufacturing location and other considerations come to the fore such as the availability of skills, convenience for logistics and intellectual property protection.[1.67] In a 2014 survey of 300 companies by the Engineering Employers Federation, one in five respondents reported that at least half of their suppliers were outside the UK. However:

- In the past three years, one in six have 're-shored' production in house, and the same proportion have switched to a UK supplier from a low-cost country;
- A further 6% were planning to re-shore – either in-house or to a UK supplier – in the next three years;
- All sizes of firms from all sectors were moving production and suppliers closer to home, with larger companies in the transport, electrical and optical equipment, and the machinery equipment sectors most likely to be reshoring.[1.68]

The percolation of potentially transformative technologies and business models throughout the manufacturing sector can be gauged through the annual surveys conducted by *The Manufacturer*.[1.69] Its latest survey included questions about 'servitisation' (the transformation of a business to compete through a combination of services and products, rather than products alone), as well as questions around what has come to be known as Manufacturing 4.0, and also the Internet of Things. Manufacturing 4.0 (or Industry 4.0, the fourth industrial revolution)[1.70] is the current trend towards high levels of automation and data exchange in manufacturing technologies, including cyber-physical systems, in creating the 'smart factory'. Within the modular structure of a smart factory, cyber-physical systems monitor physical processes, creating a virtual copy of the physical world and are capable of making decisions.

Concerns that the pace of transformation across manufacturing remains patchy have influenced the strategies of government and its agencies in a number of ways. Acute skills gaps, much reported by manufacturers, are recognised as a factor. Projections for the UK manufacturing labour force anticipate a decline from 2.7 million to 2.35 million by 2024,[1.71] as investment in capital equipment grows to improve productivity. In manufacturing, the shift towards higher-level skills is combined with continued demand for particular intermediate level skills, digital as well as technical.

1.5.2 Advanced manufacturing

A broad definition of advanced manufacturing – that which is "intensive in its use of capital and knowledge and requires a high level of technology utilisation and Research and Development (R&D)"[1.72] – can apply to all manufacturing industries, but is most commonly associated with medium- and high-tech industries. Estimates suggest around 29,000 advanced manufacturing enterprises operate in the UK, comprising around 23% of total enterprises in manufacturing (2013). A high proportion (44%) of the advanced manufacturing workforce holds high-level qualifications (qualifications at level 4 and above). This is a much higher proportion than for manufacturing as a whole (where it is 31%) and slightly higher than for the economy as a whole (41%).[1.73]

Advanced manufacturing is often reported as an area of significant potential growth for the UK economy. A range of drivers, most with a skills dimension, shape sector performance, including:

- Translating innovation into growth;
- Increasing investment in R&D;
- Meeting low carbon policies and legislation;
- Maximising export opportunities;
- Taking advantage of potentially transformative enabling technologies.

The sector is heavily influenced by developments relating to advanced technologies, such as:

- The growing 'computerisation' of production processes, as well as the prevalence of Computer-Aided Design (CAD) and bespoke software solutions;
- An increase in the resources required to test and inspect new products, as more complex materials and smaller components are used in production processes;
- A shift to shorter production runs and more tailored products, which is being driven by customer demand and facilitated by new manufacturing techniques such as 3D printing and plastic electronics.

1.65 ONS: *Statistical Bulletin Business Enterprise Research and Development*, 2014. http://www.ons.gov.uk/economy/governmentpublicsectorandtaxes/researchanddevelopmentexpenditure/bulletins/businessenterpriseresearchanddevelopment/2014 **1.66** EEF: *2016/17 UK Manufacturing Fact Card*. https://www.eef.org.uk/campaigning/campaigns-and-issues/manufacturing-facts-and-figures **1.67** Stirling Media Ltd: *UK Manufacturing Review 2015-2016*, 2015 **1.68** EEF: *Backing Britain – a manufacturing base for the future*, 2014. https://www.eef.org.uk/resources-and-knowledge/research-and-intelligence/industry-reports/backing-britain-a-manufacturing-base-for-the-future **1.69** Hennik Group: *Annual Manufacturing Report 2016*, 2015. http://www.themanufacturer.com/reports-whitepapers/annual-manufacturing-report-2016/ **1.70** Klaus Schwab: *The fourth industrial revolution*, January 2016. World Economic Forum. **1.71** UKCES: *Working Futures 2014-2024*, March 2016 **1.72** UKCES: *Sector insights: skills and performance challenges in the advanced manufacturing sector*, June 2015. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/439271/150626_AM_SLMI_exec_summary.pdf **1.73** UKCES, 2015. Ibid

Other enabling technologies with potentially major implications for advanced manufacturing include additive manufacturing, composite manufacturing, nanotechnology, silicon electronics, industrial biotechnology and artificial intelligence.

1.5.3 Support for innovation in manufacturing

At national level, the drive to help manufacturing maintain competitiveness through successful innovation has been led by the Technology Strategy Board (since 2014, under its trading name of Innovate UK). Its manufacturing and materials programme for business emphasises that:

- The UK has a strong base in high value manufacturing and advanced materials, underpinning sectors such as aerospace, automotive, energy, transport and process industries;
- The UK is an attractive location for foreign direct investment as well as an exporter of manufactured products: "we need to make sure we encourage the highest-value activities to stay in, or move back to, the UK."[1.74]

Innovate UK summarises its role as helping business to have access to the best equipment, skills and expertise, and to help test and prove solutions, as well as access the latest manufacturing and materials technologies. Its priority areas in high value manufacturing and materials are:

- Stimulating digital technologies that look at smarter, new ways of increasing manufacturing productivity, systems flexibility and resource efficiency;
- Focusing on manufacturing readiness at scale;
- Continuing support for automotive and aerospace research;
- Developing early-stage manufacturing and materials concepts that encourage companies to broaden out their innovation activities and try out ideas that could lead to new revenue lines or processes.[1.75]

In 2016, Innovate UK announced new, simplified funding mechanisms with broader scope. Following some criticism of the proportion of its support concentrated on large organisations, the first of its new funding competitions in 2016 was aimed at increasing UK SME supply chain competitiveness and growth in the manufacturing and materials sector. It also planned to enhance funding for the High Value Manufacturing (HVM) Catapult[1.76] whose seven Technology and Innovation Centres aim to help companies bridge the gap in – and accelerate the activity between – technology concept and commercialisation. The HVM Catapult also leads jointly with the Digital Catapults on upgrading UK digital manufacturing capability.

1.6 UK engineering research and innovation

Scientific, engineering and technological research and development (R&D) plays a critical role in developing the world. Research and innovation enhances countries economically by improving productivity and competitiveness. At the same time, it can address major challenges like climate change, access to shelter, food, clean water, education, communications and healthcare for developing nations, while also revolutionising services like healthcare in developed nations with ageing populations.

The UK punches above its weight as a research nation. While it represents under 0.9% of global population, 3% of R&D expenditure and 4% of researchers, it accounts for over 11% of citations and nearly 16% of the world's most highly-cited articles (second only to the United States).[1.77] Using rankings based on a combination of research, impact and teaching, the UK has up to 4 of the top 10 universities in the world, and currently 18 in the top 100.[1.78]

However, the UK lags behind international competitors when it comes to the extent of our spending on R&D. Together, businesses, universities and the government spent around £30 billion on R&D in 2014, which was equivalent to 1.67% of UK GDP. This was well below the 2.8% spent in the US and Germany, and the European target of 3%, and actual average of just over 2%.[1.79] Just under £20 billion was spent by the business sector.

1.6.1 Recognising the importance of research and innovation

Sir Paul Nurse's review of the UK Research Councils elegantly puts the case for research and its impact on life and our world:

Research in all disciplines, including the natural and social sciences, medicine, mathematics, technologies, the arts and the humanities, produces knowledge that enhances our culture and civilisation and can be used for the public good. It is aimed at generating knowledge of the natural world and of ourselves, and also at developing that knowledge into useful applications, including driving innovation for sustainable productive economic growth and better public services, improving health, prosperity and the quality of life, and protecting the environment.[1.80]

Research and innovation in the UK public and private sectors can also yield more economic benefits for society: it generates new products for market and export; it boosts productivity through more efficient machinery and processes; it creates high-value jobs; and it attracts inward investment to the UK. As Nurse continued:

Today, for advanced nations such as the UK to prosper as knowledge economies, scientific research is essential – both to produce that knowledge and also the skills and people to use it. This is why science should occupy a central place in government thinking, if the UK is to thrive in our increasingly sophisticated scientific and technological age.[1.81]

The coalition government demonstrated that it understood the importance of this underpinning role in its Science and Innovation Strategy.[1.82] This built on its earlier statement that it would put science at the heart of its long-term economic plan, committing £5.9 billion capital spending to supporting UK scientific excellence through to 2021.[1.83] Recognising that long-term sustainable growth, particularly in developed economies, rests ultimately on expanding the frontiers of knowledge alongside physical capabilities, its two key spending strands were:

- £3 billion to support individual capital projects and institutional capital to maintain the excellence of laboratories at universities and research institutes;
- £2.9 billion towards large capital projects to support a series of scientific 'Grand Challenges'.

In July 2016 Theresa May reassured the UK science community in a letter to research leaders by stating that:

...the government's ongoing commitment to science and research remains steadfast... I would like to reassure you about the government's commitment to ensuring a positive outcome for UK science as we exit the European Union.[1.84]

The value of innovation for national economic growth seems to be well established. A study into the relationship between public and private investment into science, research and

1.74 Innovate UK: *Manufacturing and Materials*, July 2016. https://www.gov.uk/government/collections/innovate-uk-manufacturing-and-materials. **1.75** Innovate UK: *Introducing our sectors – manufacturing and materials*. (blog) 15 June 2016. https://innovateuk.blog.gov.uk/2016/06/15/introducing-our-sectors-manufacturing-materials/ **1.76** Innovate UK, 2016. Ibid. **1.77** Elsevier: *International Comparative Performance of the UK Research Base* – 2013, 2013 https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/263729/bis-13-1297-international-comparative-performance-of-the-UK-research-base-2013.pdf **1.78** QS: World University Rankings, 2016/17. http://www.topuniversities.com/university-rankings/world-university-rankings/2016 **1.79** ONS: *UK Gross domestic expenditure on research and development 2014*, March 2016. http://www.ons.gov.uk/economy/governmentpublicsectorandtaxes/researchanddevelopmentexpenditure/bulletins/ukgrossdomesticexpenditureonresearchanddevelopment/2014 **1.80** BIS: *Ensuring a successful UK research endeavour. A Review of the UK Research Councils by Paul Nurse*, November 2015. https://www.gov.uk/government/publications/nurse-review-of-research-councils-recommendations **1.81** BIS, 2015. Ibid **1.82** BIS: *Our plan for growth – science and innovation*, December 2014. https://www.gov.uk/government/publications/our-plan-for-growth-science-and-innovation **1.83** BIS: *Government unveils £6 billion package for UK science and innovation* (press release). https://www.gov.uk/government/news/government-unveils-6-billion-package-for-uk-science-and-innovation December 2014

Back to Contents

innovation has shown that, at 2012 funding levels (£8 billion and £19 billion from the public and private sectors respectively), a 1% increase in public expenditure on R&D led to an increase of between 0.48% and 0.68% in private expenditure on R&D. In other words, public investment of £1 led to an increase of around £1.36 in private expenditure.[1.85]

At the same time, R&D makes its own direct contribution. The UK's public, private and voluntary sector research and technology organisations together were known to employ over 57,000 people in 2012/13 and supported £7.6 billion in gross value added contributions to UK GDP.[1.86]

Innovation was responsible for half of all UK labour productivity growth between 2000 and 2008, with 32% of that increase attributable to changes in technology resulting from science and engineering.[1.87] Such productivity growth, as we see elsewhere in this publication, is essential for wages to continue to rise and, in turn, living standards.

Investment in science and innovation yields high returns. Private rates of return to R&D investment can be as high as 20-30%, while social rates of return (spillover benefits from R&D conducted by one agent to the productivity or output of other agents) are thought to be two to three times larger still.[1.88] However, we need to remind ourselves that research and innovation activity should not only be motivated by potential economic impact, as a focus purely on economic returns will understate the overall value to society of investing in science, innovation and skills.

1.6.2 The research and innovation landscape in the UK

1.6.2.1 Government strategies

On the basis of the high-level statements above, the coalition government committed to strengthening partnerships between the public and private sector, orchestrated by its Industrial Strategy[1.89] and identification of what have been called the 'eight great technologies'[1.90] that support science and innovation. In addition, its framework for raising productivity, *Fixing the foundations: Creating a more prosperous nation*,[1.91] made the link between innovation and productivity explicit. It highlighted that the government's framework for raising productivity is built around two pillars: encouraging long-term investment in economic capital, including infrastructure, skills and knowledge; and promoting a dynamic economy that encourages innovation and helps resources flow to their most productive use.

The coalition government's commitment to science and innovation was essentially re-launched and re-badged by the Cameron government as *'One Nation Science'* – setting a clear goal for the UK to be the best place in Europe to innovate, patent new ideas and set up and expand a business.

The £5.9 billion investment in the Science and Innovation Strategy was designed to form the major part of the government's priorities for investment and support through to 2021, and framed the key principles that will underpin science and innovation policy. The £2.9 billion investment towards large capital projects to support scientific 'grand challenges' included:

- A £30 million UK commitment to an international free electron laser project;
- Additional investments in the new polar research ship and Square Kilometre Array;
- Up to £235 million for a 'Sir Henry Royce Institute for Advanced Materials' based in Manchester;
- £95 million towards European Space Agency programmes, including taking a leading role in the next European Rover mission to Mars;
- £61 million invested in the High Value Manufacturing Catapult and an additional £28 million for a new National Formulation Centre within it, to accelerate innovation and develop the next generation of technology products.

These can be seen as a combination of genuine 'science' and more applied 'innovation' and were welcomed by the UK science and innovation communities. Just as important has been the government's success to date in ring-fencing science expenditure against a back-drop of austerity reductions to many governmental department budgets.

The Science and Innovation Strategy also set out a range of measures which it claimed would develop and support the educational pipeline to ensure a supply of bright minds into science, research and the advanced workplace. These included commitments to increase the quantity and quality of STEM teachers, such as training up to 17,500 more maths and physics teachers over the life of the current Parliament, upskilling 15,000 existing non-specialist teachers, and recruiting up to 2,500 additional specialist maths and physics teachers.

Another main strand of policy has been to support and encourage more apprenticeships at the higher levels and in the right sectors where employers believe the need is greatest for skills. A number of national colleges were also announced that would provide a national focus for training apprentices and other students in key STEM sectors such as digital skills, wind energy, and advanced manufacturing.

Government policies designed to liberate and modernise this sector include enabling universities to expand and new providers to enter the higher education market. In addition, it has introduced support for those who wish to study a postgraduate course through a new loan scheme, with £10,000 available from the 2016/17 academic year, to be repaid concurrently and on a similar basis to undergraduate loans. Funding has also been provided via the Higher Education Funding Council in England to assist 28 universities to develop master's courses in engineering, computing and data science, aimed specifically at those with degrees in other subjects so that they can subsequently enter engineering and specialist ICT careers.

1.6.2.2 Sector-based strategies

Innovate UK (the trading name of the Technology Strategy Board) is the national agency for accelerating economic growth by stimulating and supporting business-led innovation. One of its government-backed vehicles for driving innovation upwards has been the programme of UK catapults.[1.92] This is a network of world-leading centres designed to transform the UK's capability for innovation in specific sectors or technology areas that can help drive future economic growth. They are constituted as not-for-profit, independent physical centres that will connect businesses with the UK's research and academic communities.

Each catapult centre specialises in a different area of technology, but all offer a space and support for businesses and researchers to collaborate and solve key sector problems and develop new products and services on a commercial scale. The first catapult (High Value Manufacturing) opened in October 2011. Since then, the ambition of the programme has evolved:[1.93]

- Innovate UK should grow the network of catapults at no more than 1-2 centres per year, with a view to having 30 catapults by 2030;

1.84 BBC: *PM wants positive outcome for science in Brexit talks*, July 2016. http://www.bbc.co.uk/news/science-environment-36915846 **1.85** Economic Insight: *What is the relationship between public and private investment in R&D?* April 2014 **1.86** Oxford Economics: *The impact of the innovation, research and technology sector on the UK economy*, 2014. http://www.airto.co.uk/docs/AIRTO%20-%20Oxford%20Economics%202014.pdf **1.87** BIS: *Estimating the effect of UK direct public support for innovation,* 2014. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/369650/bis-14-1168-estimating-the-effect-of-uk-direct-public-support-for-innovation-bis-analysis-paper-number-04.pdf **1.88** Frontier Economics: *Rates of return to investment in science and innovation*, 2014. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/333006/bis-14-990-rates-of-return-to-investment-in-science-and-innovation-revised-final-report.pdf **1.89** BIS: *Industrial strategy: early successes and future priorities*, 2014. https://www.gov.uk/government/collections/industrial-strategy-government-and-industry-in-partnership **1.90** BIS: Eight great technologies (speech by David Willets Minister for Universities and Science), 2013. https://www.gov.uk/government/speeches/eight-great-technologies **1.91** HM Treasury, 2015. https://www.gov.uk/government/publications/fixing-the-foundations-creating-a-more-prosperous-nation **1.92** Catapult centres: https://www.catapult.org.uk **1.93** p6, Dr Hermann Hauser: *Review of the Catapult network, Recommendations on the future shape, scope and ambition of the programme,* November 2014. https://www.gov.uk/government/publications/catapult-centres-hauser-review-recommendations

- Each catapult should work with Innovate UK to develop more effective SME engagement strategies, by working with local authorities and business groups and to develop clusters of activity in regions across the UK.

Currently there are 11 catapults in existence or announced (Table 1.4) which have benefited from a total public and private investment of over £1.4 billion since 2011.

InnovateUK usefully published a schematic (Table 1.5) to show how the government's innovation strands (the Industrial Strategy and the 'eight great technologies') overlapped and mapped to Innovate UK's priority investment areas at that time.[1.94]

However, it has subsequently reorganised its work into four sector groups, plus an 'open' approach:[1.95]

- Emerging and Enabling Technologies: key technologies and capabilities that will lead to the new products, processes and services of tomorrow – all with potential to create substantial industries and/or disrupt existing markets;
- Health and Life Sciences: focused on agriculture, food and healthcare, and underpinned by technologies developed in bioscience and medical research and enabled by expertise in engineering and physical sciences;
- Infrastructure Systems: these cover major global market opportunities optimising transport and energy systems and integrating them with other systems (such as health and digital);
- Manufacturing and Materials: focusing on advancing manufacturing so that R&D and technology developments can be delivered across a range of sectors to increase productivity and enhance their value in the UK;
- 'Open': funding competitions and programmes open to all innovative businesses, regardless of the technology or sector, with the aim of enabling businesses to address high-growth opportunities when a concept or idea might not fit one of these four sectors.

Table 1.4: UK catapults

Cell and Gene Therapy	based at Guy's Hospital London
Compound Semiconductor Applications	announced, to be based in Wales
Digital	based in King's Cross London
Energy Systems	based in Birmingham Business Park
Future Cities	based in Borough London
High Value Manufacturing (a network of seven centres)	Advanced Forming Research Centre based in University of Strathclyde Advanced Manufacturing Research Centre based in The University of Sheffield The Centre for Process Innovation based in Wilton Manufacturing Technology Centre based in Coventry National Composites Centre based in Bristol Nuclear AMRC based in University of Sheffield WMG Centre based in University of Warwick
Medicines Discovery	based in Alderley Park Cheshire
Offshore Renewable Energy	Wind, wave and tidal power – based in Glasgow
Precision Medicine	based in Cambridge
Satellite Applications	based at Harwell Science and Innovation Campus
Transport Systems	based in Milton Keynes

Source: Innovate UK

Table 1.5: Innovate UK's priority investment areas versus the eight great technologies and Industrial Strategy sectors

Innovate UK's priority areas	Eight great technologies	Industrial strategy sectors
Advanced materials	Advanced materials	-
Agriculture & food	Agri-science	Agricultural technologies
Biosciences	Synthetic biology	-
Built environment	-	Construction
Digital economy	Big data	Information economy, international education (education exports), professional and business services
Electronics, sensors and photonics	Robotics and autonomous systems	-
Emerging technologies	-	-
Energy	Energy storage	Nuclear, offshore wind, oil and gas
Health and care	Regenerative medicine	Life sciences
Information and communications technology	-	-
Resource efficiency	-	-
Space	Satellites	-
Transport	-	Automotive, aerospace
Urban living	-	-

Source: Technology Strategy Board

1.94 BIS: *Mapping local comparative advantages in innovation: Framework and indicators*, July 2015. https://www.gov.uk/government/publications/local-enterprise-partnerships-evidence-on-local-innovation-strengths **1.95** Technology Strategy Board: *Innovate UK: Delivery Plan – Financial Year 2016/17*, April 2016. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/514838/CO300_Innovate_UK_Delivery_Plan_2016_2017_WEB.pdf

Back to Contents

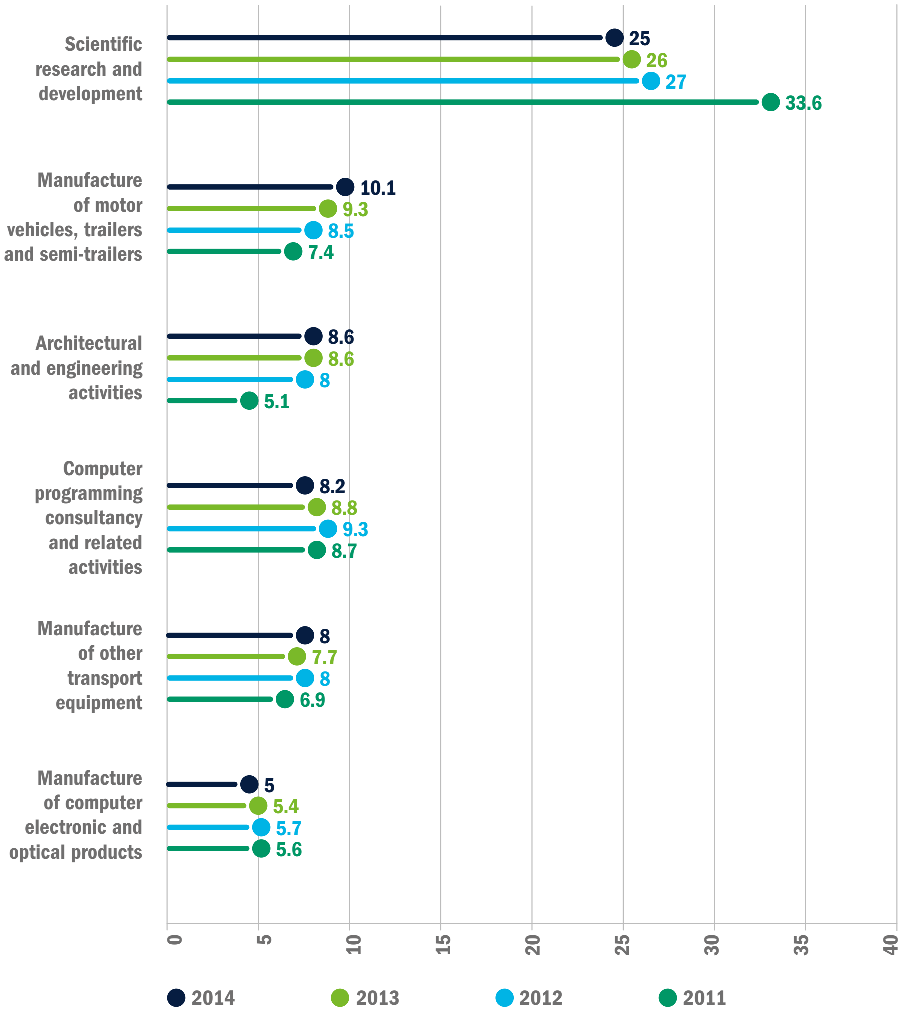
A healthy proportion of expenditure on R&D is funded by industry and performed in businesses. This has been monitored by the Office for National Statistics since 2011 (under the headline of business R&D expenditure) in a range of industrial sectors. The highest level of business R&D expenditure in 2014 came from companies classified as scientific research and development. At £5 billion, they accounted for 25% of total business R&D expenditure (Figure 1.5).[1.96] Five other industries had R&D expenditure of around £1 billion or more:

- Manufacture of motor vehicles and trailers;
- Architectural and engineering activities;
- Computer programming, consultancy and related activities;
- Manufacture of other transport equipment;
- Manufacture of computer, electronic and optical products.

These 6 industries accounted for 65% of the total UK expenditure on R&D performed in businesses in 2014.

Another way to look at this is by product group, based on data provided by the 400 largest R&D spenders, which accounted for nearly 80% of the 2014 total expenditure estimate for R&D within business operations. Since 2013, UK businesses in 24 of the 33 product groups have increased their R&D expenditure, at current prices. Pharmaceuticals continued to be the largest product group in 2014, with £3.9 billion expenditure on R&D at current prices, or 20% of UK businesses' expenditure on their R&D effort (although its level of spend has been reducing, as Figure 1.6 shows). The largest increase in an individual product group was in motor vehicles and parts, which increased for the third year in succession to over £2 billion in 2014. Another notable increase was the computer programming and information services activities group, which increased by 10% to £2.4 billion. In 2014, this was 12% of total expenditure on R&D performed within businesses.

Figure 1.5: Expenditure by UK businesses on performing R&D, by largest industries (2011-2014)



Source: ONS

1.96 ONS: *Business Enterprise Research and Development: 2014*, November 2015. http://www.ons.gov.uk/economy/governmentpublicsectorandtaxes/researchanddevelopmentexpenditure/bulletins/businessenterpriseresearchanddevelopment/2014#rd-expenditure-by-product-group

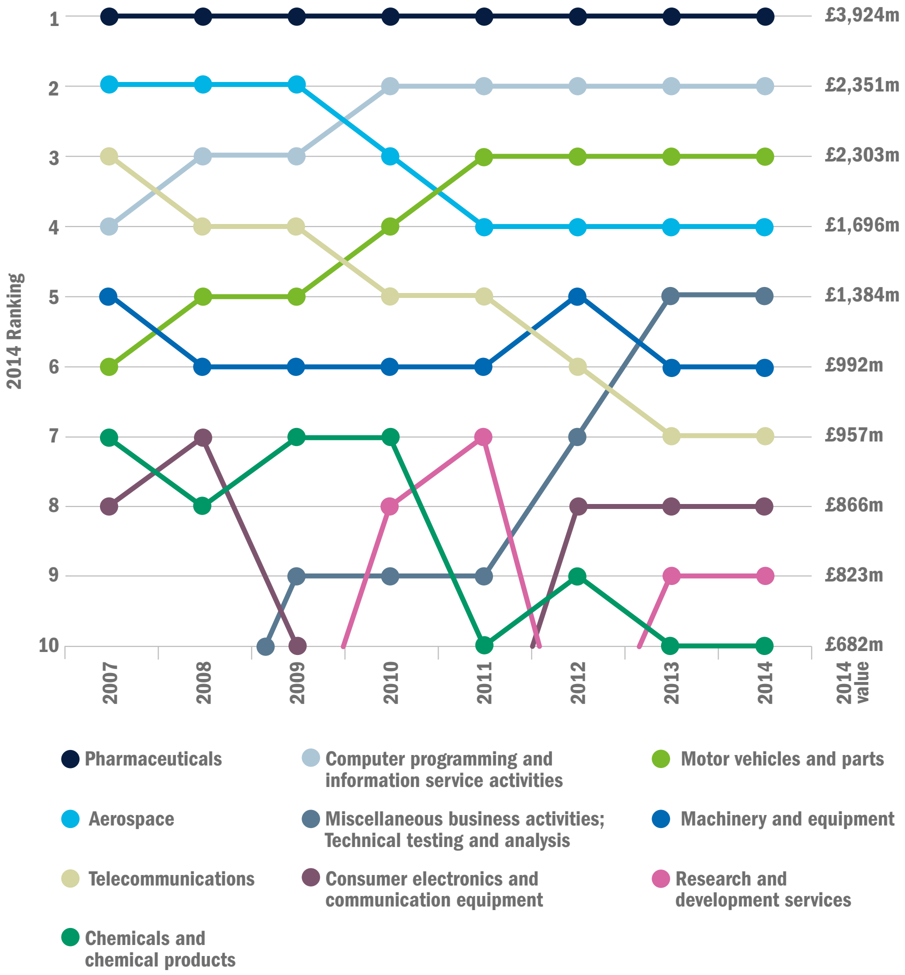
Other product groups reporting around £1.0 billion or more R&D expenditure in the UK in 2014 were:

- Aerospace – £1.7 billion (9% of total R&D expenditure);
- Miscellaneous business activities, including technical testing and analysis – £1.4 billion (7%);
- Machinery and equipment – £992 million (5%);
- Telecommunications – £957 million (5%).

These 7 product groups accounted for 68% of the total UK business R&D expenditure in 2014.

It is important to note that estimates of R&D by industry are not directly comparable with the estimates of R&D expenditure by product group. This is because businesses may report significant R&D in product groups that are different to the main classification of their business in terms of its sector.

Figure 1.6: Expenditure by UK businesses on performing R&D, in current prices, by largest product groups (2007-2014)



Source: ONS

1.6.2.3 Local strategies

Since their launch by the coalition government, the 39 Local Enterprise Partnerships (LEPs) in England have become key players in steering support for innovation at a local level. They are led by business but with local authority representation. They were created following the abolition of England's Regional Development Agencies,[1.97] with a focus on improving the responsiveness of education and skills provision to local employment demands. Following the Witty Review,[1.98] which called for a closer relationship between universities and LEPs, their focus has moved to leveraging the competitive strengths of local economies and helping local industry to access appropriate funding streams.

Many LEPs are delivering innovation initiatives through Regional Growth Fund, Growing Places Fund and City Deals, working with universities, businesses and other partners to put in place local solutions to help businesses grow. In 2014, the government announced plans to invest at least £12 billion (2015/16-2020/21) in local economies in a series of Growth Deals with LEPs, providing funds to LEPs for projects that will benefit the local area and economy.[1.99] Investment is going towards providing support for local businesses to train young people, create new jobs, build new homes and start new infrastructure projects such as transport improvements and improved broadband networks.

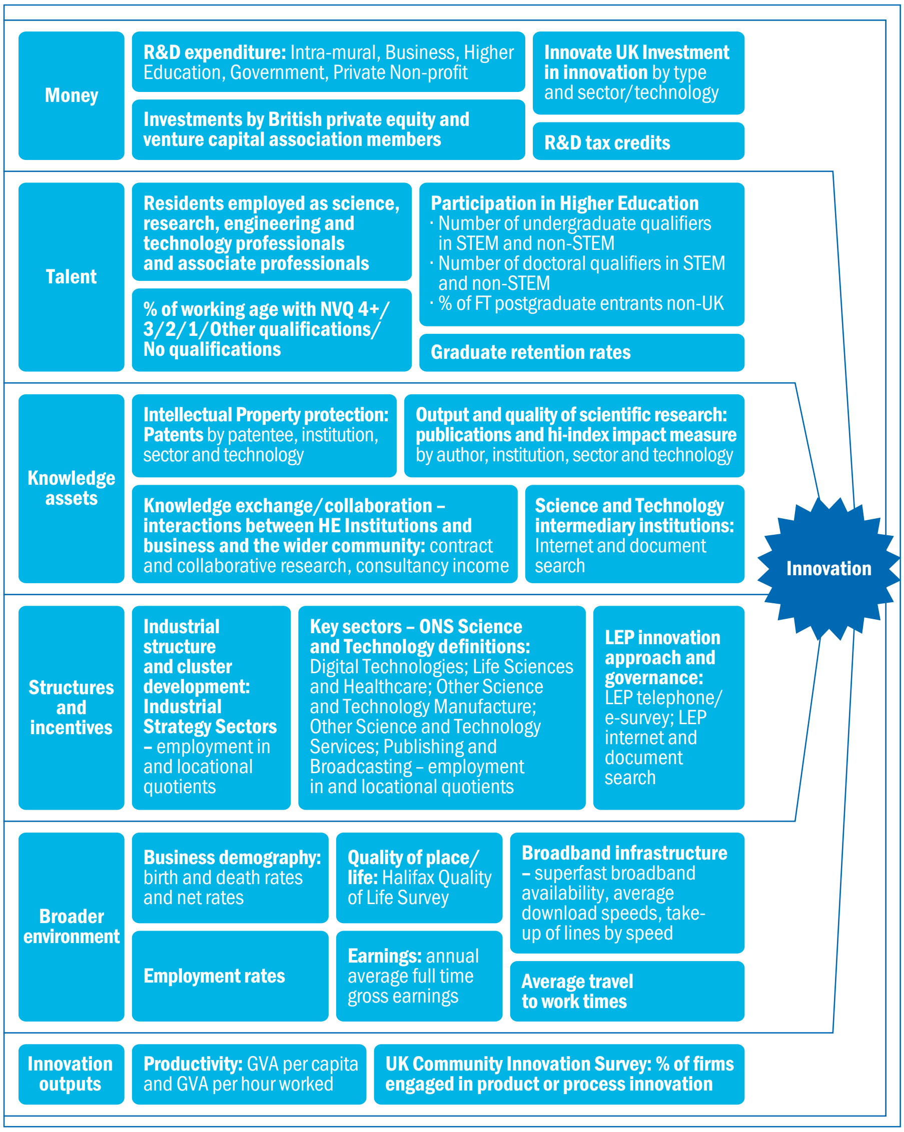
City Deals give local areas specific powers and freedoms to support economic growth, create jobs or invest in local projects, through greater local responsibility for decision-making.[1.100] The first wave of City Deals involved eight cities in 2012, with a further 20 city regions following in 2013-14. These enabled new approaches to supporting the skills and employment system to be pursued, for example using devolved funding and coordinating employer-led apprenticeships and training activity locally.

The effectiveness of their work has been supported by a project to map the comparative innovation strengths of the 39 LEP areas, to help them and their partners marshal their innovation assets to best effect[1.101] (for example, by using European Structural Funds). It is hoped that this will also reduce duplication and unproductive competition between institutions and regions.

The framework of elements of innovation capacity and indicators it established is shown in Figure 1.7. Comparative individual LEP performance data can now be collected for each indicator, to monitor appropriate innovation capacity improvement.

1.97 BIS, DCLG, Homes & Communities Agency: *2010 to 2015 government policy: Local Enterprise Partnerships (LEPs) and enterprise zones*, 2015. https://www.gov.uk/government/publications/2010-to-2015-government-policy-local-enterprise-partnerships-leps-and-enterprise-zones/2010-to-2015-government-policy-local-enterprise-partnerships-leps-and-enterprise-zones **1.98** Sir Andrew Witty: *Encouraging a British invention revolution: Sir Andrew Witty's review of universities and growth* ('Witty Review'), 2013. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/249720/bis-13-1241-encouraging-a-britishinvention-revolution-andrew-witty-review-R1.pdf **1.99** Prime Minister's Office: *Growth Deals: firing up local economies* (press release), 2014. https://www.gov.uk/government/news/growth-deals-firing-up-local-economies **1.100** Cabinet Office: *City Deals* (webpage). https://www.gov.uk/government/collections/city-deals **1.101** BIS, DCLG, Homes & Communities Agency. *2010 to 2015 government policy: Local Enterprise Partnerships (LEPs) and enterprise zones*, 2015. https://www.gov.uk/government/publications/2010-to-2015-government-policy-local-enterprise-partnerships-leps-and-enterprise-zones/2010-to-2015-government-policy-local-enterprise-partnerships-leps-and-enterprise-zones

Figure 1.7: Innovation framework: elements and headline indicators[1.102]



Source: BIS

1.6.2.4 Funding and performance of research

The Nurse Review[1.103] endorsed the role of UK research councils in supporting the research sector. It recommended that Research Councils UK (the existing loose partnership of the UK research councils) should evolve into a more formal organisation. It also called for creation of a ministerial committee to act as a forum for strategic discussions regarding science investment. These actions would facilitate communication and engagement between the research community and policymakers, and potentially enable the government to invest in a particular discipline, technology or geographic area to help UK research to realise its potential.

The government's response appeared in its 2016 Higher Education White Paper, which also introduced the Teaching Excellence Framework.[1.104] This indicated that it would create UK Research and Innovation (UKRI), a new research and innovation funding body that would allocate funding for research and innovation and act as a champion for the UK's system. The creation of UKRI, it claimed, will ensure that our research and innovation system is sufficiently strategic and agile to deliver national capability for the future, to drive discovery and growth. UKRI would incorporate the functions of the seven research councils, but also Innovate UK and HEFCE's research funding functions in England. UKRI's board would have responsibility for leading on overall strategic direction and advising the Secretary of State on the balance of funding between research disciplines. Beneath it, the councils will be responsible for the strategic leadership of their disciplines and scientific, research and innovation matters.

A further development has been reorganisation of government departments following Theresa May's appointment as Prime Minister. This moved responsibility for higher education and skills from the Department for Business, Innovation & Skills (BIS) to the Department for Education, while BIS itself was replaced by the Department for Business, Energy & Industrial Strategy (BEIS). The responsibility for research and innovation remains in BEIS.

One of the drivers of the UK's success in research is what is called the 'dual support system'. This is the current strategy whereby there is provision of competitive grant funding for research projects and programmes (through a system of proposals) and, separately, a long-term stable block grant to universities that allows them to invest more strategically in research and their capacity. Both these

1.102 BIS: Mapping local comparative advantages in innovation: framework and indicators, 2015. https://www.gov.uk/government/publications/local-enterprise-partnerships-evidence-on-local-innovation-strengths **1.103** BIS: *Ensuring a successful UK research endeavour. A Review of the UK Research Councils by Paul Nurse*, November 2015. https://www.gov.uk/government/publications/nurse-review-of-research-councils-recommendations **1.104** BIS: *Success as a Knowledge Economy: Teaching Excellence, Social Mobility and Student Choice*, May 2016. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/523546/bis-16-265-success-as-a-knowledge-economy-web.pdf investment streams must focus limited resources on excellent research. The block grant (also known as quality-related 'QR' funding) is allocated based on an assessment of the quality of research, through the Research Excellence Framework (REF) exercise, last carried out in 2014. The REF aims to examine how universities and research institutions have used their funding and resources, ie to assess the excellence of their research. Recommendations on how to enhance the way future assessments are carried out have recently been made. These are largely incremental and endorse the broad strategy currently adopted in the 2014 REF but in a more inclusive way (for example, including outputs from all research-active staff rather than a sample selected by the institution).[1.105]

Therefore, the 2014 REF is thought to give a realistic picture of the UK's research capability, based on 154 higher education institutions that were active in research and between them made 1,911 submissions at 'Unit of Assessment' level (ie research disciplines).

Overall, the REF judged 30% of submissions to be 'world leading' (4*), 46% to be 'internationally excellent' (3*), 20% 'internationally recognised' (2*) and 3% 'nationally recognised' (1*), although a criticism of the process has been that institutions do not have to submit outputs from all of their staff. For the Units of Assessment encompassing engineering research, 70% of all research outputs were classified as 'world leading' (4*) or 'internationally excellent' (3*), which represented an increase of nine percentage points compared with the equivalent exercise in 2008.[1.106]

The five Units of Assessment (UoA) related to engineering research are:

- Civil and Construction Engineering;
- Computer Science and Informatics;
- Electrical and Electronic Engineering, Metallurgy and Materials;
- General Engineering;
- Aeronautical, Mechanical, Chemical and Manufacturing Engineering.

This suggests that engineering is a strong and improving asset in the UK research portfolio. The collaborative strategy of the Engineering and Physical Sciences Research Council (EPSRC) can be seen in its current delivery plan, which focuses on:[1.107]

- Productivity – recognising that the future competitiveness and creativity of the UK economy requires the successful development of world-leading products, processes and technology which are based on discovery and innovation in the mathematical and physical sciences, ICT and engineering. EPSRC's ambitions anticipate economic and social change, and imply significant re-skilling of the UK workforce with a particular requirement to achieve technical leadership through the development of future scientists, engineers and technologists;
- Connectedness – the UK's success will be driven by new industries and services and also by innovative, more cost-effective ways of delivering existing services through transformational technologies which connect people, things and data together. This relies on discovery and innovation in the mathematical and physical sciences, computing, and engineering;
- Resilience – safeguarding future generations requires an ability to anticipate, adapt and respond to changes, natural or man-made, short or long-term, local or global. The UK's prosperity depends on the smooth and sustainable functioning of complex infrastructures such as transport, communications networks, water, energy and waste utilities. The mathematical and physical sciences, computing and engineering are fundamental to the new thinking and innovation needed to build a truly resilient nation and to increase UK competitiveness;
- Health – mental and physical wellbeing affect quality of life, the resilience of communities and the productivity of the nation. Advances based on new research in the engineering and physical sciences will revolutionise the ability to manage our own health, maintain healthier behaviours and environments, and transform the way healthcare is delivered. Novel technologies and materials will continue to improve our ability to predict, diagnose and treat disease. Research will deliver better quality of life, higher standards of affordable care and will drive UK growth through new products and services.

Collaboration with industry in order to drive innovation is also seen through EPSRC's support for high-potential technologies in its 'Centres for Innovative Manufacturing.' These are part of its approach to maximising the impact of innovative research for the UK, supporting existing industries and opening up new industries and markets in growth areas. A range of centres have received funding to develop collaborations with industry, carry out feasibility studies and support research projects. EPSRC's core funding is used to help secure further investment from industry and other funders.[1.108]

1.105 BEIS: *Building on Success and Learning from Experience An Independent Review of the Research Excellence Framework*, July 2016. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/541338/ind-16-9-ref-stern-review.pdf **1.106** Technopolis: *Assessing the economic returns of engineering research and postgraduate training in the UK, Final report*, March 2015. https://www.epsrc.ac.uk/newsevents/pubs/econreturnsengresreport/ **1.107** EPSRC: *EPSRC Delivery Plan 2016/17-2019/20 Science for a Successful Nation*, 2016. https://www.epsrc.ac.uk/newsevents/pubs/epsrc-delivery-plan-2016-17-2019-20/ **1.108** EPSRC: *EPSRC Centres for Innovative Manufacturing* (webpage). https://www.epsrc.ac.uk/research/centres/innovativemanufacturing/

1.7 Industrial strategy

A government industrial strategy is broadly a high-level intention with the aim of supporting or developing certain industries to enhance economic growth. UK governments have taken a number of different approaches to industrial strategy in the past, but in recent decades a climate of non-intervention has tended to prevail. It was therefore noteworthy that one of Theresa May's first actions as Prime Minister was to create the new Department for Business, Energy and Industrial Strategy (BEIS). This has tantalised some observers to think that it marks a re-introduction of more overt industrial strategy, as opposed to non-intervention.

Whether it really does so is uncertain yet. So far, the new industrial strategy that we have witnessed appears to feature the following aspirations:

- Stricter merger and acquisition rules, with more emphasis on the public-interest in foreign take-overs;
- New corporate governance structures, including consumer and employee representation on boards, and also greater transparency around executive pay;
- Higher productivity, partly by developing the UK science and research base;
- Delivery of more infrastructure projects and building more houses;
- Supporting regional development, chiefly through cities and economic areas outside London.[1.109]

As with almost every area of government policy, any evolving industrial strategy could be radically impacted by the UK's decision to leave the EU.

1.7.1 Recent UK industrial strategies

The use of the phrase 'industrial strategy' by the current government contrasts immediately with David Cameron's government, within which the then Secretary of State with responsibility for industrial policy preferred the phrase 'industrial approach' (which could be characterised as non-interventionist but engaged). Prior to that, the coalition government came to power as the UK was recovering from the recession. Sir Vince Cable, Secretary of State at BIS, preferred a sector-based (or 'vertical') industrial strategy as a way to boost economic growth. He suggested that the government had confidence in the market to enable economic growth, but intervention was required where markets failed or were sub-optimal.

The coalition government's industrial strategy featured five key themes:

- Boosting the development of 11 key sectors;
- Supporting the development of 'eight great technologies';
- Increasing access to finance for businesses;
- Developing the skills of employees in key sectors;
- Using public procurement to create opportunities for UK firms and supply chains.

Support for specific sectors was a particularly important aspect of the strategy. The government identified sectors that it thought were strategically important and had a commitment to innovation. Its intervention in each of these sectors was to involve a high-level forum that brought together industry leaders and policymakers to identify barriers to growth and other sector-specific issues, and to commit to the development of specific training institutions or initiatives within the sector, providing often match-funded financial commitments.

In parallel, 'eight great technologies' funds were allocated to support particular key technologies[1.110] which were big data, satellites, robots, modern genetics, regenerative medicine, agricultural technologies, advanced materials and energy storage.

These were reinforced by more cross-cutting or 'horizontal' underpinning strategies including the Regional Growth Fund, Productivity Plan and more regional or local activity in the form of Growth Deals, City Deals and more support for LEPs as described earlier.

Another element to industrial strategy at that time was a stated high-level intent to 'rebalance' Britain's economy, lessening the UK's dependence on the City and other service sector industries and instead increasing the contribution of manufacturing and construction. An underlying rationale was that if another banking crisis was around the corner, it would not have such great impact if the economy was more balanced. However, the GDP figures shown elsewhere in this publication suggest that little rebalancing has occurred, and the service sector's contribution to growth has continued to increase ahead of those of other sectors such as manufacturing.

1.7.2 What now for industrial strategy?

It is tempting to assume that Theresa May's government will develop and employ a more overt industrial strategy and, in differentiating itself from its predecessors, that such a strategy may be more horizontally focused than the dominantly sector-based or vertical approach of the coalition government. However, only some ideas of the potential direction of travel can be discerned at this early stage, and the implications of Britain's exit from the EU have tended to occupy much of the attention.

Some clues were given in terms of BEIS's responsibilities regarding industrial strategy:[1.111]

- Business and enterprise: *cementing the UK's position as the best place in Europe to start and grow a business – by supporting local growth, entrepreneurs, and making it easier for businesses to resolve disputes quickly and easily;*
- Competitiveness: "developing a long-term industrial strategy, supporting competitive markets, cutting red tape and protecting intellectual property";
- Science and innovation: *ensuring that the UK is the best place in Europe to innovate, maintaining our world-leading research and science base to drive growth and productivity while reforming the system to maximise value from our investments.*

The Secretary of State at BEIS has emphasised that:

- Successful industries should be recognised and supported (including automotive, aerospace and space);
- Scientific research must be encouraged through support for relevant institutions;
- New industries and technologies must be allowed to develop;
- The interests of consumers must be protected and served through innovation and competitive pricing;
- The contribution of employees and businesses owners must be recognised;
- Local areas must be encouraged through support for transport, skills and a 'pro-business' culture;
- The UK's strength in terms of a base for regulations and standards should be retained.[1.112]

He subsequently emphasised that the government's industrial strategy could be more horizontal in approach than sectoral and that many of the policies and decisions would be less about particular industries or sectors, but more cross-cutting in nature.[1.113]

A Cabinet Committee on industrial strategy was established in July 2016 with representation across government to ensure that industrial

1.109 House of Commons Library: *Industrial strategy briefing paper*, October 2016. http://researchbriefings.files.parliament.uk/documents/CBP-7682/CBP-7682.pdf **1.110** BIS: *Eight great technologies: Infographics* (webpage). https://www.gov.uk/government/publications/eight-great-technologies-infographics **1.111** Prime Minister: *Machinery of Government: Merging the Department of Energy and Climate Change with the Department for Business, Innovation and Skills to create the Department for Business, Energy and Industrial Strategy*, July 2016. http://qna.files.parliament.uk/ws-attachments/539038%5Coriginal%5CDBEIS%20Explanatory%20Note.pdf **1.112** BEIS: *New ministerial team to develop industrial strategy* (speech), August 2016. https://www.gov.uk/government/speeches/new-ministerial-team-to-develop-industrial-strategy **1.113** BEIS: *The importance of industrial strategy* (speech), September 2016. https://www.gov.uk/government/speeches/the-importance-of-industrial-strategy

strategy has input from all policy areas. Its inaugural press release summarised its priorities:

The new committee, which will bring together Secretaries of State from more than 10 government departments, will help to drive forward an industrial strategy that will aim to put the United Kingdom in a strong position for the future, promoting a diversity of industrial sectors and ensuring the benefits of growth are shared across cities and regions up and down the country.

In particular, it will focus on addressing long-term productivity growth, encouraging innovation and focusing on the industries and technologies that will give the UK a competitive advantage.[1.114]

Of particular interest, it was later commented that the Committee had agreed that "solving the puzzle of how to improve productivity would be at the heart" of the government's industrial policies and it is prominent in the recent green paper.[1.115]

The 2016 Autumn Statement by the Chancellor of the Exchequer recognised that raising productivity is essential for a high-skill and high-wage economy and included announcement of a National Productivity Investment Fund to be spent on innovation and infrastructure over the next five years.[1.116] Chancellor Philip Hammond indicated that there would be additional £4.7 billion investment in research and development, ramping up to an extra £2 billion per year by 2021. Many infer that this is designed to offset potential reductions in European funding. The aspects of infrastructure mentioned for investment included additional house-building, fibre network enhancement, road and rail network improvements including digital rail signalling, and support for further development of low-emission and autonomous vehicle use. The government has also asked the National Infrastructure Commission to explore which emerging technologies have the most potential for improving infrastructure productivity, and to make recommendations on potential actions to support deployment.[1.117]

UK government industrial strategy consultation: ten pillars

1. Investing in science, research and innovation
2. Developing skills
3. Upgrading infrastructure
4. Supporting businesses to start and grow
5. Improving procurement
6. Encouraging trade and inward investment
7. Delivering affordable energy and clean growth
8. Cultivating world-leading sectors
9. Driving growth across the whole country
10. Creating the right institutions to bring together sectors and places

Contemplation of a future UK industrial strategy is currently impossible without also considering the potential impact of the UK's exit from the European Union, which is treated further in the next section. A new report *Engineering a future outside the EU: securing the best outcome for the UK*, on behalf of the UK engineering community and in response to the referendum result, applauds the government's apparent renewed focus on industrial strategy, and reinforces the need for it. As Sir John Parker, Chair, Anglo-American notes:

With the new and unique set of challenges we face following the vote on the EU, an industrial strategy will be even more critical for our companies competing in hi-tech global markets.[1.118]

Throughout the consultation which informed the report, one opportunity was pointed to repeatedly. Namely, the development of a new industrial strategy, through partnership with academia and industry, as a route to enabling engineering to maintain and increase its contribution to economic development and social progress after the UK leaves the EU. The report calls for an industrial strategy that communicates that the UK is forward-looking, open for business and an active and welcoming partner for the international research, innovation and business communities.

Engineering a future outside the EU: industrial strategy[1.119]

With or without the EU referendum vote, the engineering community is strongly supportive of the government's decision to develop a new industrial strategy.

An industrial strategy should be the primary vehicle for taking advantage of global opportunities during and beyond this period of transition. The strategy should:

- Be based on, and enable, strong partnership between government, industry, the academic research base and Research and Innovation Organisations (RIOs);
- Ensure that the UK has sound supporting infrastructure – physical and digital – with a clear pipeline of major projects and at a price that is affordable and makes it attractive to do business in the UK;
- Secure the delivery of the skills and knowledge base needed to enable the UK to maximise opportunities outside of the EU;
- Incorporate policies and frameworks designed to lower the costs of doing business, make the UK an attractive place to invest in and promote the particular advantages of investment in the UK;
- Adopt a systems approach to the strategy that encompasses national and local government and all regions of the UK and also promotes fair and inclusive economic growth;
- Align policies across all relevant government departments, including the Foreign & Commonwealth Office, Department for International Trade, Department for Exiting the European Union, the Home Office, Department for Transport, Department for Education, Department for Business, Energy and Industrial Strategy, and HM Treasury;
- Deliver a powerful message that the UK is forward looking, open for business, and an active and welcoming partner for the international research, innovation and business communities.

1.114 Prime Minister's Office: *New Cabinet committee to tackle top government economic priority* (press release), August 2016. https://www.gov.uk/government/news/new-cabinet-committee-to-tackle-top-government-economic-priority **1.115** Rowena Mason: *Theresa May stresses importance of reducing north – south productivity gap*, Guardian August 2016. https://www.theguardian.com/politics/2016/aug/02/theresa-may-stresses-importance-of-reducing-north-south-productivity-gap: HM government: *Building our Industrial Strategy* (green paper), January 2017. https://beisgovuk.citizenspace.com/strategy/industrial-strategy/ **1.116** HM Treasury: *Autumn Statement 2016: Philip Hammond's speech*, November 2016. https://www.gov.uk/government/speeches/autumn-statement-2016-philip-hammonds-speech **1.117** HM Treasury: *Letter from the Chancellor to the National Infrastructure Commission (NIC) on a new study*, November 2016. https://www.gov.uk/government/publications/letter-from-the-chancellor-to-the-national-infrastructure-commission-nic-on-a-new-study **1.118** Engineering the Future: *Engineering a future outside the EU: securing the best outcome for the UK*, October 2016. http://www.raeng.org.uk/publications/reports/engineering-a-future-outside-the-eu **1.119** Engineering the Future: ibid

1.8 Leaving the European Union

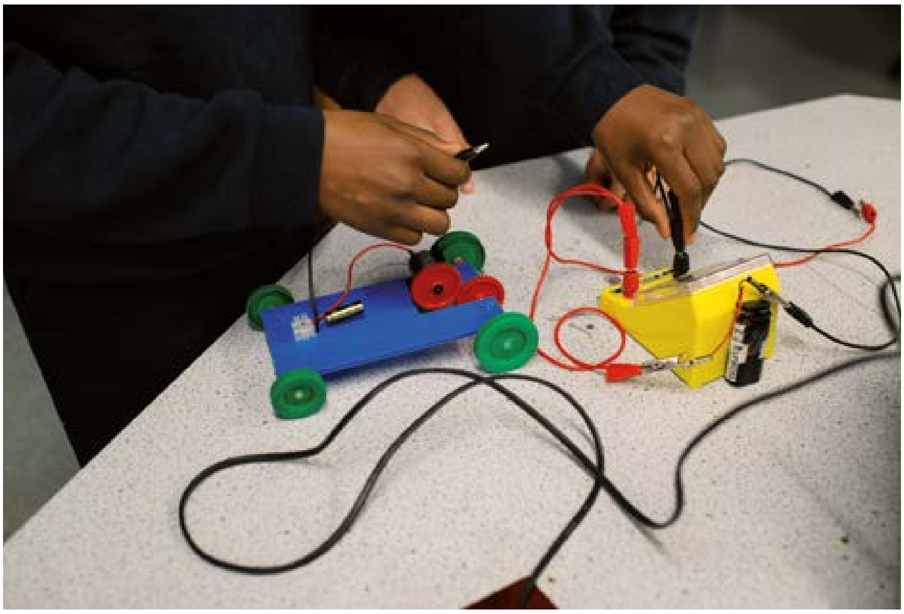
A number of potential vulnerabilities to the health of UK engineering in the light of the UK's decision to leave the EU are highlighted in other chapters of this publication. In particular, these are in relation to the potential impact on the supply of skilled labour, while appreciating that there could also be impacts on the demand for labour too, hence adding to levels of uncertainty.

A number of these issues are articulated in the Engineering the Future alliance's report, which aims to provide evidence-based advice to the government about the opportunities and risks associated with Brexit for the engineering community. It focuses on three themes – people and skills, finance and funding, and standards and regulations. The first of these addresses many issues that will be familiar to readers of this publication, not least because Engineering the Future draws upon the 2016 edition for certain data and its discussion of potential supply and demand of higher level skills.[1.120]

Concerns are expressed that exit from the EU will exacerbate the shortage of skills at intermediate and high levels into engineering. Although plans to increase the number and level of apprenticeships are welcome, and to allow greater numbers of students in higher education, the supply of skills from within the UK is insufficient to fulfil the demand from employers. Companies therefore rely on hiring employees from the EU, and the rest of the world, some of whom will have studied in the UK. If such recruitment becomes more difficult, due to changes to immigration rules, the shortage can only become worse.

The report notes that half of the roles on the Home Office Shortage Occupation List are either in engineering sectors or allied professions, signalling this reliance on inward migration of labour. The current requirement of a minimum £30,000 salary for a role to qualify impacts adversely on certain regions and nations, such as Northern Ireland, where earnings are lower than elsewhere in the UK. A number of specific recommendations are made in order to offset any potential reductions to the inward migration of labour into the engineering sector.

Another area highlighted in this publication is higher education, where the UK has world-class universities and a strong history of innovation, drawing in large numbers of international students. Engineering and technology subjects have high proportions of international students, especially from outside the EU but also significantly from EU countries. There are several potential aspects to the impact of leaving the EU on the propensity of EU (or other international) students to study here:



- There could be increases to the tuition fees currently enjoyed by EU students, which could have a direct impact by reducing our education export value;
- Their potential eligibility to work in the UK is a key factor – as we identify in Chapter 10, there is a particular exposure for engineering to the current supply of high-level skills from international students who remain in the country to work here;
- There could be damage to perceptions of the UK's reputation as an open and welcoming country in which to study or work.

There is an additional risk in that postgraduate taught courses and research programmes in engineering are highly dependent on international students for their viability. Were such programmes to become unviable, this would have a knock-on effect on the opportunities for UK graduates to study at these levels, but also potentially damage the future research and academic workforce, which is the destination for some of these postgraduates. The proportion of the academic engineering workforce which is of EU origin is higher than the average across all disciplines, especially amongst many high-performing universities in terms of research. There is a wider concern about the UK's ability to attract top researchers internationally, as it is accepted that the capacity and talent in the research base are much healthier with free mobility of researchers, especially into the UK.

There have been concerns in several quarters about UK research's future access to European Union funding, such as the Horizon 2020 programme.[1.121] This has led to assurances from the government that the Treasury will underwrite the payments of such awards where projects continue beyond the UK's departure from the EU.[1.122] However, there remain fears for the longer term in relation to the UK's participation in collaborative research, of which the EU is a prime funder. This also extends to collaborative innovation projects supported by EU funds, which not only UK universities but also UK SMEs are particularly successful in accessing. EU-supported collaboration has been powerful in driving forward innovation which is addressing global challenges such as climate change. In short, Brexit poses some threats to the future capacity of UK science and engineering innovation.

Engineering the Future also details possible impacts of the UK's departure on the markets for engineering-related exports, whether those are specific engineering products or services, but also on issues like energy security, as the UK has become reliant upon a highly internationally inter-connected energy system. There is also clearly the issue of EU funding for development and infrastructure projects in the UK, within which engineering has in many cases played a key role.

The key recommendations of the report are that the government offers the maximum clarity where it can during the next two to three years to reduce the inherent uncertainties. At the same time, the report recommends that the government develops a new industrial strategy that will enable engineering to play to its full potential in contributing to economic and social development.[1.123]

1.120 EngineeringUK: *The state of engineering 2016*, December 2015. http://www.engineeringuk.com/Research/ **1.121** THE: *Brexit: future EU research money for UK may rely on free movement*, July 2016. https://www.timeshighereducation.com/news/brexit-future-eu-research-money-uk-may-rely-free-movement **1.122** HM Treasury: *Chancellor Philip Hammond guarantees EU funding beyond date UK leaves the EU*, August 2016. https://www.gov.uk/government/news/chancellor-philip-hammond-guarantees-eu-funding-beyond-date-uk-leaves-the-eu **1.123** Engineering the Future: *ibid*

Part 1 – Engineering in Context
2 Contributions to UK economy and employment

Key points

Data for 2015 confirms that, after years of emerging from the recession, growth in the UK engineering sector has continued and even accelerated in the last year.

Sector growth and make-up

The number of engineering enterprises (that are registered for VAT and/or PAYE) grew by 7% across the UK between 2014 and 2015, reaching over 650,000. Relative growth was fastest in London but still strong in almost every region and UK nation. Only in Northern Ireland have numbers failed to exceed pre-recession levels.

Engineering has almost kept pace with overall growth across the UK, with engineering enterprises comprising 27% of all UK enterprises, and over 30% in the South East.

Small employers dominate – over 80% of engineering enterprises are micro-companies and the vast majority classified as SMEs. Yet over 40% of all those working for engineering enterprises are employed by a company larger than an SME.

Economic contribution

Financially, registered engineering enterprises contributed £1.2 trillion or 24% of the total UK turnover from VAT- or PAYE-registered enterprises: 2% up on the previous year. Over 7 years, the increase has been in excess of 15%, and over 20% in some regions. The sector punches well above its weight in terms of its proportion of turnover regionally. It contributes up to 40% of total enterprise turnover in several regions and Wales, although not in service-dominated London.

Within the engineering sector, manufacturing fuels this growth and contribution, comprising nearly half of the turnover.

Around 5.7 million people work in engineering enterprises, with a strong focus on manufacturing. With around 19% of all those employed in registered enterprises in engineering, the sector continues to be a major employer.

In terms of overall gross value added (GVA), engineering activity contributed over £430 billion in 2015: around 26% of the UK total and 2% more than the previous year. London and the South East, in particular, account for large shares of the sector's GVA.

Multiplier effects

Every additional £1 of GVA created by engineering activity creates a total of £2.45 GVA, thanks to 'multiplier effects'. These are the indirect effects of supply chain activity and induced impacts through employment. In terms of effects on employment, every additional person employed through growth in engineering activity supports a total of 2.74 jobs.

The fiscal and societal contributions of engineering activity and the employment it provides, using this snapshot, are vast and well exceed pre-recession levels.

2.1 Introduction

This chapter aims to capture the extent and scale of the engineering sector and its contributions to the UK. It provides data on the number and size of engineering enterprises (for the most recent available year), the numbers of people they employ and their financial turnover – broken down by nation and English region where possible. From this, we have estimated the gross value added (GVA) of each engineering activity to the UK economy, and looked at how the activity of the supply chain and employment factors amplify this contribution.

2.2 Engineering enterprises and employment

2.2.1 Number of engineering enterprises in the UK

Table 2.1 shows that the total number of enterprises registered for VAT and/or PAYE in the UK increased by 8.2% between 2014 and 2015, reaching almost 2.45 million enterprises. There was growth in all the nations of the UK and all regions of England. Growth was fastest in London, the North East and Yorkshire and the Humber, at over 10%, and lowest in Northern Ireland at less than 1%. Numerically, the greatest concentration of enterprises in 2015 was in London, at nearly 445,000. This was followed by the South East, with nearly 380,000. Interestingly, the highest rates of growth were experienced in both the region with the most enterprises (London) and the region with the fewest (the North East).

Looking back seven years, enterprise numbers across the UK grew by just under 14%, with the fastest growth between 2014 and 2015. There was growth in each of the seven years in all the English regions and all UK nations except Northern Ireland, where the number of enterprises in 2015 remained below its 2009 level. The strongest growth rates over the period were in London (31%), Scotland (over 15%) and the North East of England (nearly 15%), but most regions enjoyed double digit rises. Although this presents an apparently healthy picture overall, it should be remembered that this data covers the UK's emergence from the recession and financial crisis, and much of this growth could represent recovery to pre-2008 levels.

Focusing just on engineering enterprises, Table 2.2 shows an increase in number across the UK of over 42,000 between 2014 and 2015. In 2015, there were just over 650,000 – an increase of nearly 7% on the previous year. One third of these enterprises were in London and the South East (each with over 110,000 enterprises), while there were fewest in Northern Ireland, the North East and Wales. Reflecting the all-enterprise numbers, growth in the number of engineering enterprises was highest in London, at just over 10% between 2014 and 2015, and similar in the North East. The annual growth rate in engineering enterprise numbers was 7% when aggregated for England, quite similar in Scotland and Wales, but much lower at 1% in Northern Ireland.

Since 2009, growth in the number of engineering enterprises by region and nation was broadly similar to the overall picture. However, there were some pronounced variations. The number of engineering enterprises in Northern Ireland declined more sharply than the overall decline in enterprise numbers (9% compared with 5%). Growth in engineering enterprise numbers was also lower than growth for all enterprises in the North West, Yorkshire and the Humber and in the East and West Midlands. In contrast, growth numbers for engineering enterprises were notably greater in Scotland (ten percentage points higher at 25%), in the North East and in London (both five percentage points higher than for overall growth, with growth in London as high as 36% over the seven years).

Table 2.1: Number of VAT and/or PAYE registered enterprises (2009-2015) – UK[2.1]

Nation	Region	2009	2010	2011	2012	2013	2014	2015	Change over 1 year	Change over 6 years
England		1,844,030	1,797,910	1,780,820	1,842,665	1,862,100	1,950,030	2,116,300	8.5%	14.8%
	North East	57,425	55,865	54,770	56,420	56,430	59,340	65,735	10.8%	14.5%
	North West	211,915	204,990	201,060	205,690	206,815	216,665	235,955	8.9%	11.3%
	Yorkshire and The Humber	152,475	148,855	146,605	150,060	150,715	156,320	172,215	10.2%	12.9%
	East Midlands	147,980	143,310	140,940	144,510	145,295	151,770	164,690	8.5%	11.3%
	West Midlands	177,195	171,410	167,585	171,200	171,750	177,880	191,580	7.7%	8.1%
	East	217,925	213,635	210,845	216,595	217,605	226,940	242,975	7.1%	11.5%
	London	339,185	331,535	334,395	359,880	372,380	400,925	444,880	11.0%	31.2%
	South East	337,380	330,375	328,015	337,810	339,965	352,720	377,445	7.0%	11.9%
	South West	202,550	197,935	196,605	200,500	201,145	207,470	220,825	6.4%	9.0%
Wales		92,005	89,370	87,430	88,575	87,685	90,205	97,800	8.4%	6.3%
Scotland		145,745	144,565	144,650	150,455	151,105	156,765	168,270	7.3%	15.5%
Northern Ireland		70,620	68,525	67,960	67,490	66,690	66,645	67,045	0.6%	-5.1%
UK total		2,152,400	2,100,370	2,080,860	2,149,185	2,167,580	2,263,645	2,449,415	8.2%	13.8%

Source: ONS (IDBR)

Table 2.2: Engineering enterprises registered for VAT and/or PAYE (2009-2015) – UK[2.1]

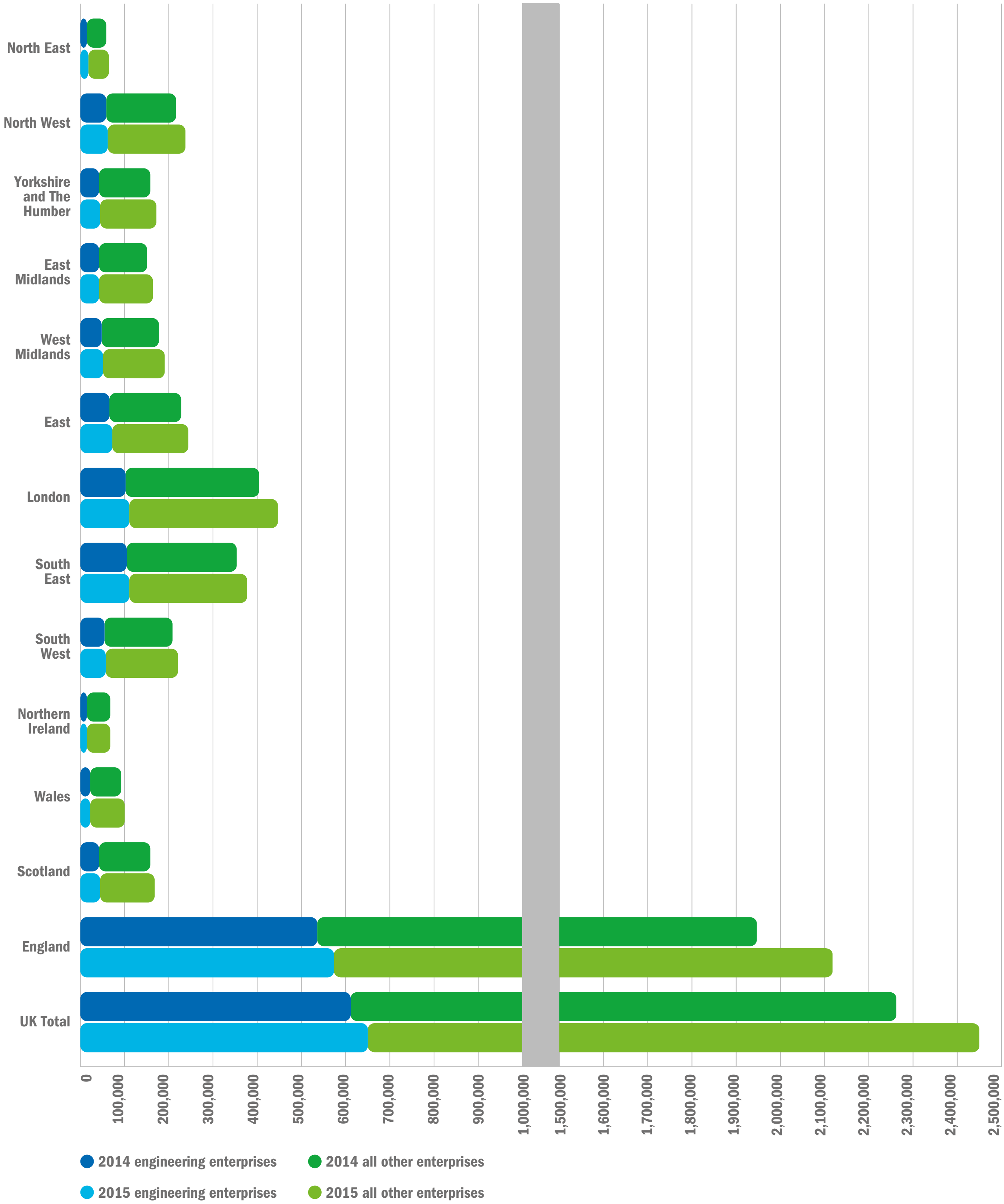
Nation	Region	2009	2010	2011	2012	2013	2014	2015	Change over 1 year	Change over 6 years
England		495,645	479,715	471,275	491,585	501,720	530,900	568,185	7.0%	14.6%
	North East	15,545	15,010	14,545	15,275	15,675	16,995	18,635	9.6%	19.9%
	North West	55,315	53,240	51,365	53,065	53,895	57,090	60,765	6.4%	9.9%
	Yorkshire and The Humber	40,080	38,825	37,770	38,855	39,330	41,015	43,970	7.2%	9.7%
	East Midlands	40,600	39,050	38,075	38,850	39,280	40,825	43,155	5.7%	6.3%
	West Midlands	48,380	46,415	44,945	46,105	46,625	48,650	51,430	5.7%	6.3%
	East	63,625	61,930	60,495	62,415	63,040	66,235	70,305	6.1%	10.5%
	London	81,680	78,640	79,190	87,175	91,775	100,495	110,890	10.3%	35.8%
	South East	98,005	95,500	94,535	98,020	99,800	104,865	111,450	6.3%	13.7%
	South West	52,415	51,105	50,355	51,825	52,300	54,730	57,585	5.2%	9.9%
Wales		21,375	20,595	20,115	20,540	20,525	21,535	23,180	7.6%	8.4%
Scotland		36,125	35,920	36,180	38,490	39,840	42,250	45,290	7.2%	25.4%
Northern Ireland		15,860	15,290	14,870	14,705	14,355	14,235	14,425	1.3%	-9.0%
UK total		569,005	551,520	542,440	565,320	576,440	608,920	651,080	6.9%	14.4%

Source: ONS (IDBR)

2.1 Numbers rounded to nearest 5

Back to Contents

Figure 2.1: VAT and/or PAYE registered enterprises and proportion that are engineering enterprises, by region and UK nation (2014-2015)



Source: ONS (IDBR)

Figure 2.1 and Table 2.3 consider the number of VAT- and/or PAYE-registered engineering enterprises as a proportion of comparable registered enterprises, by nation and English region. For the UK overall, just under 27% of all registered enterprises were engineering enterprises in 2015, which was fractionally lower than in 2014. This proportion did not vary highly between different regions or nations, from just under 30% in the South East to just under 22% in Northern Ireland and 24% in Wales. While London had the highest number of engineering enterprises in the UK, this amounted to just under a quarter of all enterprises within the capital.

The extent of change in engineering enterprise numbers as a proportion of all enterprises between 2014 and 2015 was not large for any region or nation. It ranged from fractional growth in Northern Ireland (+0.2%) to a decline of 0.7% in the East Midlands and Yorkshire and the Humber.

Broadly, this data shows that the number of engineering enterprises has tended to grow in almost all regions and nations, albeit in most cases slightly more slowly than the total number of enterprises. In Northern Ireland, however, this trend is reversed: there was an overall decline in numbers but this was slightly less marked in engineering.

Table 2.3: Number of VAT and/or PAYE registered engineering enterprises as a proportion of all enterprises (2014-2015) – UK

Nation	Region	Proportion of enterprises that are engineering enterprises		Change over 1 year
		2014	2015	
England		27.2%	26.8%	-0.4%
	North East	28.6%	28.3%	-0.3%
	North West	26.3%	25.8%	-0.6%
	Yorkshire and The Humber	26.2%	25.5%	-0.7%
	East Midlands	26.9%	26.2%	-0.7%
	West Midlands	27.3%	26.8%	-0.5%
	East	29.2%	28.9%	-0.3%
	London	25.1%	24.9%	-0.1%
	South East	29.7%	29.5%	-0.2%
	South West	26.4%	26.1%	-0.3%
Wales		23.9%	23.7%	-0.2%
Scotland		27.0%	26.9%	0.0%
Northern Ireland		21.4%	21.5%	0.2%
UK total		**26.9%**	**26.6%**	-0.3%

Source: ONS (IDBR)

Back to Contents

The number of engineering enterprises in different broad industrial groupings is shown in Table 2.4. For the UK as a whole, in both 2014 and 2015, information and communication was the largest engineering group, accounting for 28.7% of all engineering enterprises in 2015. This was followed by construction with 26.1%. These proportions were essentially the same as the previous year. The total number of engineering enterprises in manufacturing did increase, but as a proportion of all engineering enterprises, it decreased slightly to 19%.

Across the home nations and English regions, the numbers of engineering enterprises remained the same or increased in all of the major industrial groups, with the exception of a very small decrease in the number of manufacturing enterprises in London.

Table 2.4: Number of engineering enterprises in selected industrial groups, by region/nation (2013–2015) – UK

Home nation/ English region	Year	Overall	Manufacturing	Mining and quarrying	Construction	Information and communication	All other industrial groups
North East	2014	16,995	3,905	45	4,465	2,535	6,035
	2015	18,635	3,970	50	4,905	2,755	6,835
North West	2014	57,090	13,750	70	14,400	12,385	16,485
	2015	60,765	13,825	70	15,385	13,140	17,930
Yorkshire and the Humber	2014	41,015	11,320	85	11,540	7,860	10,210
	2015	43,970	11,435	90	12,325	8,475	11,315
East Midlands	2014	40,825	11,335	80	11,635	7,825	9,945
	2015	43,155	11,335	80	12,320	8,295	10,880
West Midlands	2014	48,650	13,665	50	12,410	10,435	12,095
	2015	51,430	13,705	55	13,015	11,015	13,385
East	2014	66,235	13,165	85	19,745	17,905	15,335
	2015	70,305	13,185	90	20,930	19,245	16,605
London	2014	100,495	11,845	160	18,800	51,285	18,405
	2015	110,890	11,735	160	21,365	56,475	20,825
South East	2014	104,865	17,530	105	26,895	36,395	23,935
	2015	111,450	17,640	100	28,780	38,705	25,895
South West	2014	54,730	11,475	100	16,100	13,700	13,360
	2015	57,585	11,525	100	16,955	14,330	14,465
England	2014	530,900	107,990	780	135,990	160,325	125,805
	2015	568,185	108,355	795	145,980	172,435	138,135
Wales	2014	21,535	5,130	60	7,065	3,640	5,650
	2015	23,180	5,310	65	7,505	3,935	6,205
Scotland	2014	42,250	7,810	240	9,880	8,110	16,210
	2015	45,290	8,015	230	10,445	8,745	17,475
Northern Ireland	2014	14,235	3,700	80	6,005	1,405	3,045
	2015	14,425	3,740	90	5,945	1,490	3,160
UK total	2014	608,920	124,630	1,160	158,940	173,480	150,710
	2015	651,080	125,420	1,180	169,875	186,605	164,975
Share of total UK engineering enterprises	2014	-	20.5%	0.2%	26.1%	28.5%	24.8%
	2015	-	19.3%	0.2%	26.1%	28.7%	25.3%

Source: ONS (IDBR)

2.2.2 Size of engineering enterprises

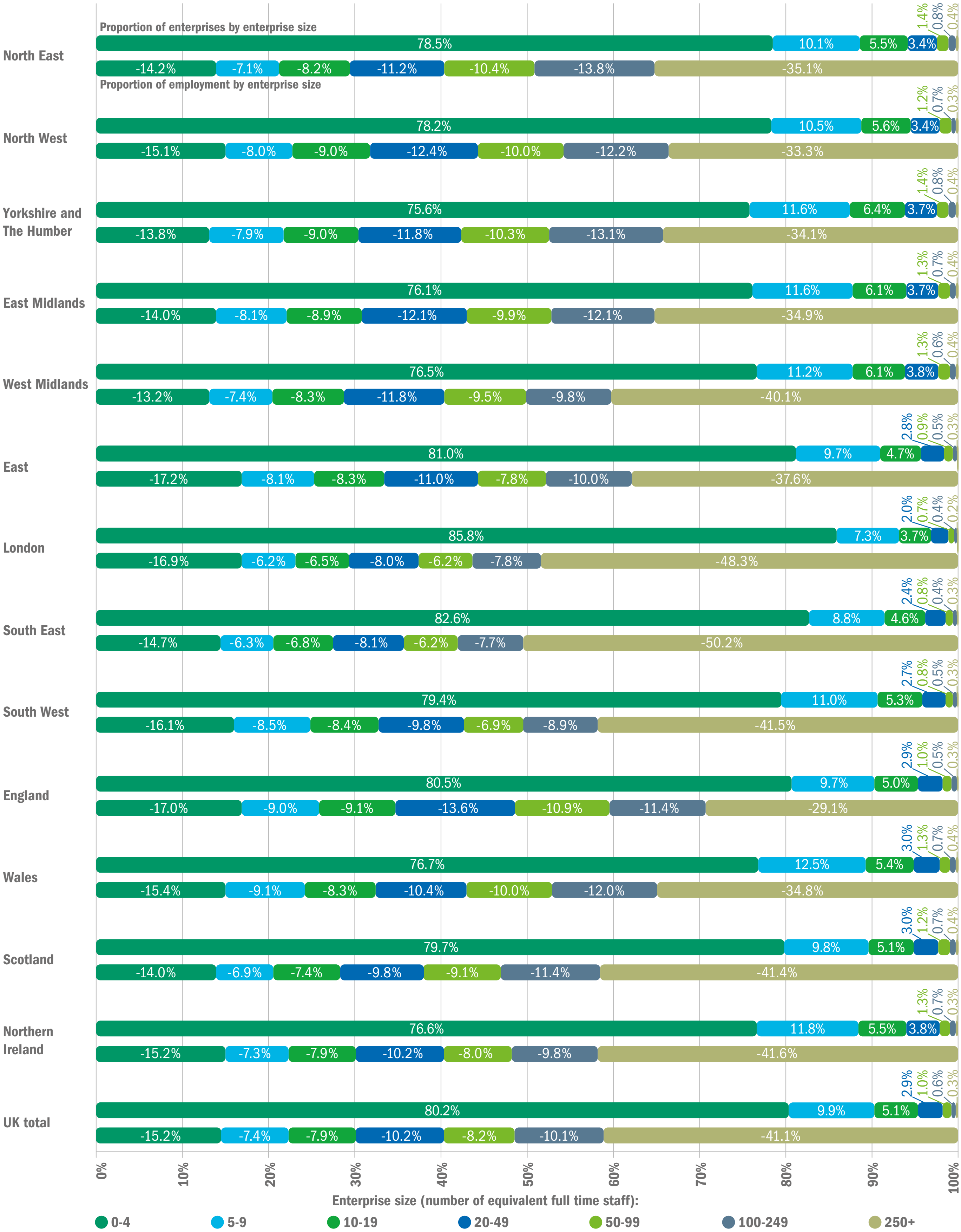
2.2.2.1 Size by number of employees

Figure 2.2 illustrates the profile of VAT- and/or PAYE-registered enterprises in the UK in terms of the number of people they employed in 2015. The left side of the chart shows employment share by size of enterprise, while the right side shows the number of engineering enterprises of those sizes. This shows the numerical dominance of small employers within the engineering sector. Across the UK, 80% of registered engineering enterprises are micro-companies with four or fewer employees, and the vast majority are SMEs (with fewer than 250 employees). This profile was broadly similar across the regions and nations, but highest in London, where 85% of enterprises have four or fewer employees. It was somewhat lower in Yorkshire and the Humber and the East Midlands, at just over 75%.

However, while most engineering enterprises in the UK are micro-companies, the majority of employees in 2015 (52%) worked for an enterprise which employed 100 or more people. Most of those (42%) worked for an enterprise with 250 or more employees, ie not an SME. The proportion of UK engineering employees working for a micro-company also increased by four percentage points between 2014 and 2015 for the UK as a whole.

However, these proportions do vary by region. The proportion of people employed by micro-companies ranged from 13% to 17% across the regions. Employment in enterprises larger than SMEs was highest in the South East and in London (both accounting for around half of all employees), but only 29% in Northern Ireland, and 35% or less in many regions. (Across the UK, these larger companies account for an average of 41% of employees). Areas with the highest proportions employed in larger engineering enterprises tended to have relatively smaller proportions of people employed in medium-sized enterprises (50-250 employees).

Figure 2.2: Distribution of employment in VAT and/or PAYE registered engineering enterprises: Proportion of enterprises by enterprise size (upper) and proportion of total employment by enterprise size (lower), by region/nation (2015) – UK



Source: ONS (IDBR)

Back to Contents

2.2.2.2 Size of engineering enterprises by turnover

Engineering enterprises registered for VAT and/or PAYE in the UK generated £1.24 trillion of turnover in the 2014/15 financial year – an increase of 2.4% on the previous year. This represents 24.2% of the UK's £5.12 trillion total turnover from all registered enterprises, which itself had grown almost 5% in the same period. Analysis by UK nation and English region (Table 2.5) shows that the greatest proportion of total turnover came from the South East (at £248 billion) and London (£241 billion). Unsurprisingly, these are the regions with the largest numbers of engineering enterprises.

Compared with the previous year, the West Midlands had the greatest increase in turnover for engineering enterprises (+36%). There were steady increases in most other regions, but a fall of 10% in London and 6% in the North West. Interestingly, both of these regions experienced growth in the number of engineering enterprises during this period. Therefore, increases or decreases in regional turnover cannot be entirely linked to growth or decline in enterprise numbers.

Since 2009, turnover from engineering enterprises increased by 15% for the UK as a whole. While the turnover for most English regions and Scotland increased substantially over this period, it was essentially static in Wales, Northern Ireland, Yorkshire and the Humber and Eastern England. In the North East, turnover fell by 20%. This suggests that recovery of the engineering sector since the recession has been far from uniform across the UK.

Table 2.6 shows the turnover generated by engineering enterprises in 2014 and 2015 as a proportion of the total turnover from all companies, by devolved nation and English region. In 2015, engineering enterprises accounted for nearly a quarter (24.2%) of the turnover of all registered enterprises in the UK, which was 0.6 percentage points lower than 2014.

Engineering enterprises were strongest in the West Midlands, where they delivered almost 40% of total turnover. They were also very strong in Wales (38%), the South East and Scotland (both 34%). Despite showing the largest turnover in monetary terms, London's was much lower proportionally (just 12.5% of all turnover). This reflects the very high contribution of the service sector to the London economy.

Positive and negative changes in these proportions were seen between 2014 and 2015 in different regions and UK nations. The proportion of total turnover contributed by engineering enterprises rose strongly in the North East (by eight percentage points) and in the West Midlands (nearly six percentage points), while the largest falls were in the South East and North West at around 3% lower, and London at just under 2% lower. Presumably, these fluctuations are the net effect of a series of changes in the engineering sector and other sectors of the economy in the different regions and nations. For example, the decline in London and the South East could well be explained by faster growth in the service sector.

Table 2.5: Turnover (£ millions) of VAT and/or PAYE registered engineering enterprises, by region/nation (2009-2015) – UK

Nation	Region	2009	2010	2011	2012	2013	2014	2015	Change over 1 year	Change over 6 years
England		924,826	985,443	911,125	931,530	1,003,080	1,047,383	1,070,460	2.2%	15.7%
	North East	38,171	35,807	27,065	27,694	28,790	30,255	30,511	0.8%	-20.1%
	North West	82,209	85,323	77,817	81,790	89,851	100,721	94,551	-6.1%	15.0%
	Yorkshire and The Humber	64,580	62,709	56,371	60,684	62,974	64,271	66,188	3.0%	2.5%
	East Midlands	60,270	62,046	58,742	59,817	62,315	64,018	69,424	8.4%	15.2%
	West Midlands	93,612	82,572	77,024	82,262	93,161	96,043	131,280	36.7%	40.2%
	East	109,521	117,366	109,177	115,142	122,467	105,773	108,322	2.4%	-1.1%
	London	198,958	232,880	207,274	213,518	237,333	268,095	240,784	-10.2%	21.0%
	South East	211,568	237,578	230,367	223,813	235,763	241,327	247,940	2.7%	17.2%
	South West	65,936	69,162	67,289	66,811	70,427	76,876	81,460	6.0%	23.5%
Wales		35,082	35,412	32,139	33,997	35,344	34,143	35,194	3.1%	0.3%
Scotland		94,329	107,388	98,805	113,339	113,503	109,064	113,077	3.7%	19.9%
Northern Ireland		19,357	19,377	18,082	17,939	17,819	18,490	19,447	5.2%	0.5%
UK		1,073,594	1,147,619	1,060,151	1,096,806	1,169,747	1,209,082	1,238,178	2.4%	15.3%

Source: ONS (IDBR)

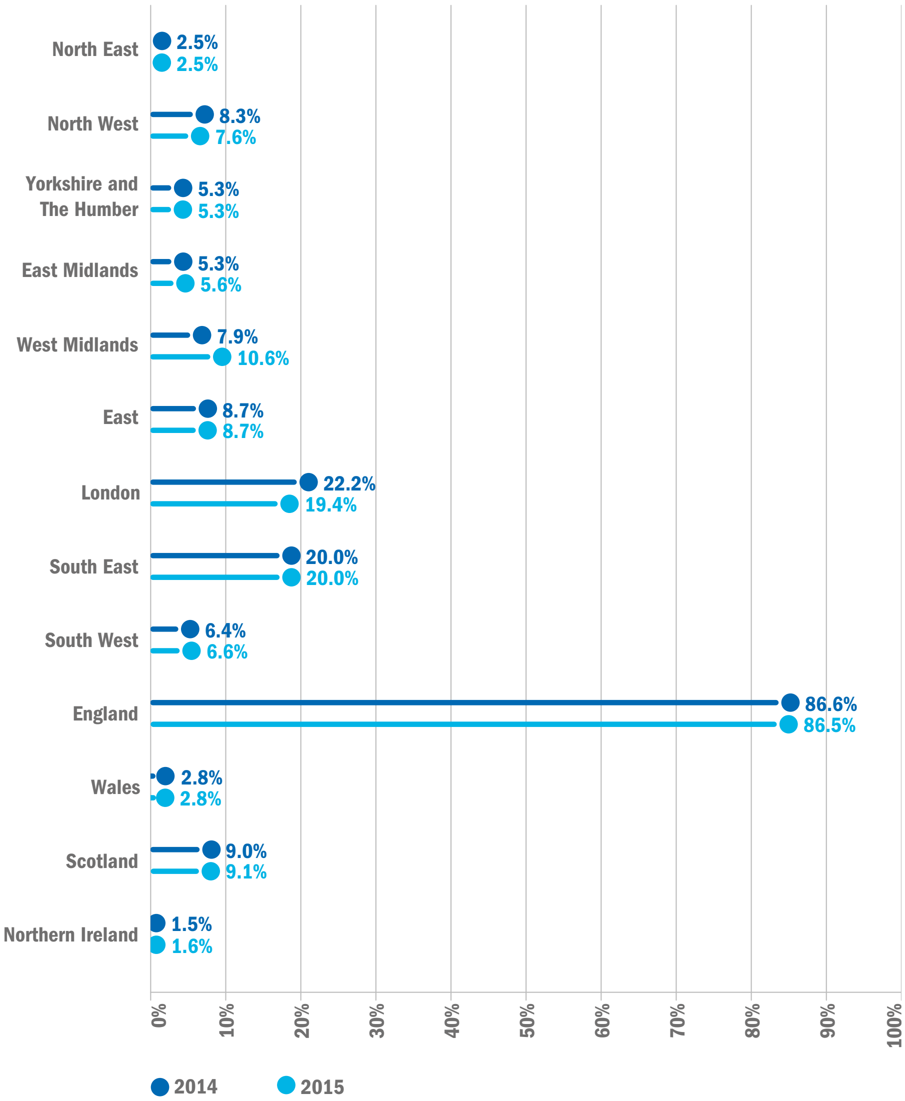
Table 2.6: Turnover of VAT- and/or PAYE registered engineering enterprises as a proportion of turnover in all enterprises, by region/nation (2014-2015) – UK

Nation	Region	Proportion of enterprises that are of engineering enterprises		Percentage point change
		2014	2015	
England		23.8%	23.1%	-0.7
	North East	21.5%	29.5%	8.0
	North West	32.0%	29.1%	-2.9
	Yorkshire and The Humber	22.1%	20.2%	-2.9
	East Midlands	28.3%	29.1%	0.8
	West Midlands	34.1%	39.9%	5.8
	East	29.5%	29.5%	0.0
	London	14.4%	12.5%	-1.7
	South East	37.1%	34.0%	-3.0
	South West	28.0%	29.1%	1.1
Wales		39.6%	38.4%	-1.2
Scotland		33.7%	33.5%	-0.2
Northern Ireland		28.7%	29.6%	0.9
UK		24.8%	24.2%	-0.6

Source: ONS (IDBR)

Figure 2.3 demonstrates how each nation and region contributes to the total turnover of the UK's engineering enterprises, and how this changed between 2014 and 2015. England's engineering enterprises accounted for 86% of total UK engineering turnover, with a concentration financially of enterprises in London and the South East. Both these regions contributed around a fifth of total engineering turnover in 2015, although the contribution from London in 2015 did decline from the year before. The strong relative growth in the West Midlands is also evident, while in most regions there was relatively little year-on-year change proportionally.

Figure 2.3: Share of UK turnover of VAT and/or PAYE registered engineering enterprises, by region/nation (2014-2015)



Source: ONS (IDBR)

Looking at turnover by sub-group (Table 2.7) shows that manufacturing accounted for 47% (£587 billion) of all engineering enterprise turnover in 2015. Construction contributed 12%, information and communication 15%, and other sub-sectors around 20%. Compared with 2014, the manufacturing sector's turnover increased by over 2 percentage points, while the contributions of construction and information and communication remained constant.

Turnover in different sectors within individual regions or UK nations changed quite substantially between 2014 and 2015. For example, there was a large increase in manufacturing in the West Midlands. Mining and quarrying saw a particularly large shift, which is to be expected given its small size as a proportion of the total engineering turnover.

Table 2.7: Turnover (£ millions) of VAT and/or PAYE registered engineering enterprises in selected industrial groups, by region/nation (2014-2015) – UK

Nation	Region	Year	Total	Manufacturing	Mining and quarrying	Construction	Information and communications	All other industrial groups
England		2014	1,047,384	482,259	65,167	132,519	178,336	189,102
		2015	1,070,460	524,248	33,313	134,973	182,665	194,851
		Change	2.2%	8.7%	-48.9%	1.9%	2.4%	3.0%
	North East	2014	30,255	18,713	530	4,148	1,118	5,747
		2015	30,511	19,623	628	4,553	1,194	4,492
		Change	0.8%	4.9%	18.5%	9.8%	6.8%	-21.8%
	North West	2014	100,721	60,770	252	11,540	6,461	21,698
		2015	94,551	55,904	365	10,583	7,275	20,359
		Change	-6.1%	-8.0%	44.7%	-8.3%	12.6%	-6.2%
	Yorkshire and The Humber	2014	64,271	37,074	640	10,849	4,028	11,681
		2015	66,188	37,683	657	11,917	4,021	11,857
		Change	3.0%	1.6%	2.7%	9.8%	-0.2%	1.5%
	East Midlands	2014	64,019	42,169	745	11,038	3,851	6,216
		2015	69,424	43,850	2,160	12,789	3,820	6,765
		Change	8.4%	4.0%	190.0%	15.9%	-0.8%	8.8%
	West Midlands	2014	96,044	56,807	280	13,035	4,919	21,003
		2015	131,280	94,626	431	9,820	5,458	20,905
		Change	36.7%	66.6%	54.2%	-24.7%	11.0%	-0.5%
	East	2014	105,773	59,209	90	20,200	11,718	14,557
		2015	108,322	57,874	113	21,721	11,559	17,011
		Change	2.4%	-2.3%	25.3%	7.5%	-1.4%	16.9%
	London	2014	268,096	73,559	59,677	24,156	77,962	32,741
		2015	240,784	76,565	26,277	24,214	79,074	34,600
		Change	-10.2%	4.1%	-56.0%	0.2%	1.4%	5.7%
	South East	2014	241,328	99,156	2,630	27,686	56,806	55,050
		2015	247,940	100,075	2,363	29,703	57,484	58,261
		Change	2.7%	0.9%	-10.2%	7.3%	1.2%	5.8%
	South West	2014	76,877	34,803	324	9,868	11,474	20,409
		2015	81,460	38,048	319	9,673	12,780	20,603
		Change	6.0%	9.3%	-1.5%	-2.0%	11.4%	1.0%
Wales		2014	34,143	23,236	281	4,197	1,804	4,625
		2015	35,194	23,946	368	4,610	1,694	4549
		Change	3.1%	3.1%	30.9%	9.8%	-6.1%	-1.6%
Scotland		2014	109,065	25,906	19,182	9,599	3,138	51,240
		2015	113,077	28,773	16,012	10,153	3,430	54,652
		Change	3.7%	11.1%	-16.5%	5.8%	9.3%	6.7%
Northern Ireland		2014	18,490	9,906	170	4,047	893	3,474
		2015	19,447	9,907	669	4,381	883	3,607
		Change	5.2%	0.0%	293.7%	8.3%	-1.1%	3.8%
UK total		2014	1,209,082	541,308	84,801	150,362	184,171	248,440
		2015	1,238,178	586,874	50,362	154,116	188,672	257,659
		Change	2.4%	8.4%	-40.6%	2.5%	2.4%	3.7%
Share of total UK engineering enterprises turnover		2014	-	44.8%	7.0%	12.4%	15.2%	20.5%
		2015	-	47.4%	4.1%	12.4%	15.2%	20.8%
		Change	-	2.6%	-2.9%	0.0%	0.0%	0.3%

Source: ONS (IDBR)

2.3 Employment in engineering in the UK

In March 2015, there were nearly 5.7 million employees working for VAT- and/or PAYE-registered engineering enterprises in the UK (Table 2.8). This represented just over 19% of total UK employment in all registered enterprises (just under 30 million people). The 2015 figure for engineering enterprises was an increase numerically of slightly over 2% on 2014 and the fourth consecutive year of growth, although it remains some 4% below the 2009 figure. As a proportion of total employment, it has remained relatively consistent, at just over 19%, for the last three years.

The regions with the greatest employment numbers in engineering enterprise in 2015 were the South East (over one million employees) and London, which are the regions with the largest number of employers. All the other regions of England except the North East had between 400,000 and 500,000 employees in engineering, along with Scotland. However, numbers in Northern Ireland, the North East of England and Wales were only one third to one half this size.

Over the past year, London saw the strongest growth in employment numbers, at 3.6%. London also had the strongest growth across the seven years (over 17%). The South East, Scotland and the East Midlands also saw growth of over 3%. In fact, there was growth in all English regions and UK nations except Northern Ireland. This pattern very broadly resembles that seen for the number of engineering enterprises, although the differences in detail reflect changes in employment in existing enterprises as well as from new enterprises.

Table 2.9 records the percentage of people employed in engineering enterprises in 2014 and 2015 as in a proportion of total UK employment in VAT or PAYE in registered enterprises. Across the UK as a whole, 19.1% of employment comes from engineering enterprises. Most nations and regions reflect this figure, with 18-20% of employment coming from engineering enterprises. However, the

Table 2.9: Employment in engineering enterprises as a proportion of employment in all VAT and/or PAYE registered enterprises, by region/nation (2014-2015) – UK

Nation	Region	Proportion of total employment in engineering enterprises		Percentage point change over 1 year
		2014	2015	
England		19.3%	19.2%	-0.1
	North East	17.5%	17.7%	0.2
	North West	19.2%	18.7%	-0.5
	Yorkshire and The Humber	17.9%	17.7%	-0.2
	East Midlands	19.0%	19.1%	0.1
	West Midlands	21.2%	20.8%	-0.4
	East	18.7%	18.6%	-0.1
	London	14.7%	14.8%	0.1
	South East	24.9%	24.7%	-0.2
	South West	22.7%	22.2%	-0.5
Wales		19.6%	19.3%	-0.3
Scotland		18.9%	19.0%	0.1
Northern Ireland		18.0%	17.4%	-0.6
UK total		**19.3%**	**19.1%**	-0.2

Source: ONS (IDBR)

Table 2.8: Employment in VAT and/or PAYE registered engineering enterprises, by region/nation (2009-2015) – UK

Nation	Region	2009	2010	2011	2012	2013	2014	2015	Change over 1 year	Change over 6 years
England		5,084,000	4,848,000	4,657,000	4,700,000	4,700,000	4,797,000	4,910,000	2.4%	-3.4%
	North East	189,000	175,000	159,000	164,000	167,000	168,000	171,000	2.3%	-9.3%
	North West	559,000	540,000	489,000	489,000	493,000	511,000	518,000	1.4%	-7.3%
	Yorkshire and The Humber	462,000	423,000	403,000	410,000	404,000	418,000	421,000	0.8%	-8.8%
	East Midlands	427,000	399,000	382,000	385,000	388,000	392,000	404,000	3.1%	-5.3%
	West Midlands	550,000	519,000	497,000	491,000	500,000	501,000	508,000	1.5%	-7.6%
	East	657,000	633,000	607,000	604,000	607,000	535,000	546,000	1.9%	-17.0%
	London	717,000	661,000	668,000	695,000	704,000	813,000	841,000	3.6%	17.4%
	South East	1,018,000	1,000,000	961,000	969,000	960,000	981,000	1,014,000	3.4%	-0.4%
	South West	505,000	497,000	491,000	493,000	477,000	479,000	486,000	1.5%	-3.8%
Wales		223,000	208,000	206,000	203,000	201,000	203,000	206,000	1.6%	-7.4%
Scotland		435,000	408,000	403,000	408,000	409,000	409,000	423,000	3.2%	-2.8%
Northern Ireland		153,000	144,000	125,000	121,000	120,000	120,000	119,000	-0.4%	-22.0%
UK		5,895,000	5,608,000	5,391,000	5,432,000	5,431,000	5,529,000	5,659,000	2.3%	-4.0%

Source: ONS (IDBR)

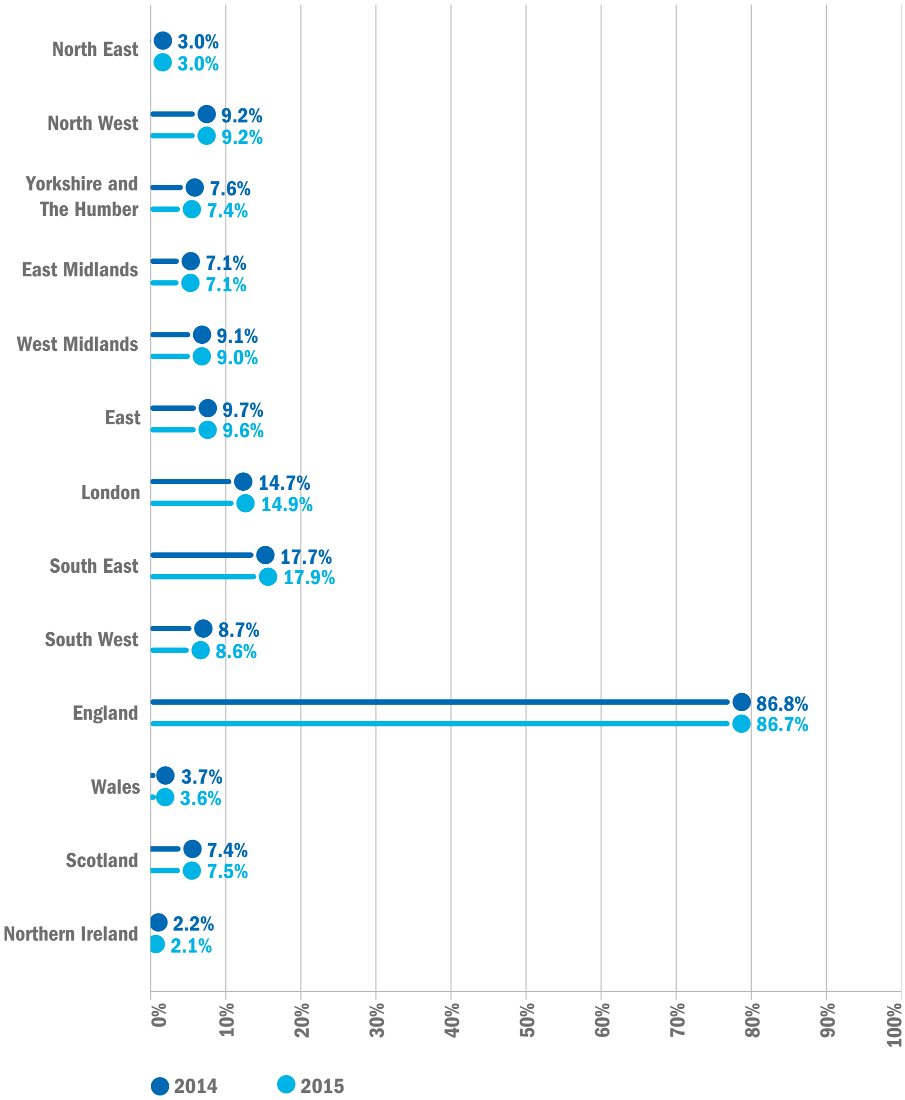
Back to Contents

proportion is lower in London, at 15% (reflecting its high focus on service sector enterprises) and in Northern Ireland (17%), but higher in the South East and the South West (25% and 22% respectively).

Changes in these proportions between 2014 and 2015 were very modest. Many regions experienced a very marginal decline or no significant change, and no nations or regions grew by more than a fraction of a percentage point. This picture was very similar to the trend observed the previous year.

Figure 2.4 shows how engineering employment is distributed across the UK, in terms of the proportion of employees. There was minimal change between 2014 and 2015, at just 0.1 or 0.2 of a percentage point. Over a longer period, however, differences are more substantial. Between 2009 and 2015, Northern Ireland lost half a percentage point of its share of engineering employment, while England gained a similar amount. Within England there were marginal declines (of up to 0.4 percentage points) in all regions (and 1.5% in the East of England) but these were compensated by increases in the South East (0.6 percentage points) and especially London (up 2.7 percentage points). This suggests a gradual shift of engineering employment south-eastwards.

Figure 2.4: Share of total engineering employment in the UK by region/nation (2014-2015)



Source: ONS (IDBR)

In terms of number of employees, engineering employment remains concentrated in manufacturing, which accounted for 43% – equivalent to just over 8% of all UK employment in 2015. Employment in ICT-related and other industrial groups each accounted for nearly 20% of engineering employment numbers. Construction-related employment accounted for 17%, while mining and quarrying accounted for just 1% (Table 2.10). There was very minimal change in these proportions at UK level between 2014 and 2015.

Looking at the number of employees in different engineering sectors regionally shows an increase in manufacturing employment between 2014 and 2015 in all but three areas of the UK: Yorkshire and the Humber, the South East and Northern Ireland. Despite the small decrease in the headline number of manufacturing jobs to just under 350,000, the South East still has the largest proportion of manufacturing-related engineering jobs (nearly 15% or 1 in 6 of the UK total). The next largest concentrations by number were in the West Midlands and the North West, each accounting for around 12% of all engineering employment in manufacturing, followed by Yorkshire and the Humber and the East Midlands. Despite its large scale in terms of overall engineering employment, London had only 7% of the manufacturing jobs in the engineering sector in 2015.

Construction followed a broadly similar pattern, but with a higher proportion of engineering-related jobs in London (12%), an area which, together with the South East, made up over 30% of all construction employment. ICT-related engineering jobs were more concentrated still in London (36%) and the South East (26%), with just 9% in the East of England. All other industrial groups accounted for 19% of engineering-related employment in the South East, 14% in London and 13% in the South West. Unsurprisingly, the geographical distribution of engineering employment in mining and quarrying was very different, with almost half of the UK's total in Scotland.

Table 2.10: Employment in VAT and/or PAYE registered engineering enterprises by selected industrial groups, by region/nation (2014-2015) – UK

Nation	Region	Year	Total	Manufacturing	Mining and quarrying	Construction	Information and communications	All other industrial groups
England		2014	4,797,000	2,060,000	25,000	810,000	973,000	929,000
		2015	4,904,000	2,073,000	28,000	832,000	1,002,000	968,000
		Change	2.2%	0.6%	14.6%	2.7%	2.9%	4.3%
	North East	2014	168,000	88,000	2,000	31,000	12,000	34,000
		2015	171,000	94,000	2,000	32,000	13,000	30,000
		Change	2.1%	6.9%	2.5%	1.7%	5.2%	-11.2%
	North West	2014	511,000	273,000	1,000	95,000	49,000	93,000
		2015	517,000	280,000	1,000	86,000	56,000	94,000
		Change	1.2%	2.5%	26.9%	-9.2%	12.6%	1.4%
	Yorkshire and the Humber	2014	418,000	247,000	2,000	70,000	36,000	63,000
		2015	420,000	242,000	2,000	74,000	38,000	66,000
		Change	0.6%	-2.2%	2.4%	4.4%	7.6%	3.5%
	East Midlands	2014	392,000	236,000	3,000	65,000	36,000	52,000
		2015	404,000	237,000	6,000	68,000	36,000	56,000
		Change	2.9%	0.3%	111.3%	4.4%	1.8%	8.0%
	West Midlands	2014	501,000	286,000	1,000	80,000	42,000	91,000
		2015	508,000	293,000	1,000	75,000	44,000	94,000
		Change	1.4%	2.5%	10.2%	-6.1%	3.1%	3.7%
	East	2014	535,000	225,000	1,000	110,000	97,000	103,000
		2015	545,000	220,000	1,000	115,000	97,000	112,000
		Change	1.8%	-2.0%	15.2%	4.8%	-0.7%	8.9%
	London	2014	813,000	164,000	9,000	118,000	371,000	150,000
		2015	841,000	168,000	9,000	123,000	383,000	158,000
		Change	3.5%	2.2%	3.9%	4.2%	3.1%	5.2%
	South East	2014	981,000	351,000	5,000	158,000	268,000	199,000
		2015	1,013,000	348,000	4,000	175,000	273,000	213,000
		Change	3.3%	-0.8%	-4.3%	10.9%	1.8%	6.6%
	South West	2014	479,000	110,000	2,000	82,000	61,000	144,000
		2015	485,000	191,000	2,000	84,000	62,000	146,000
		Change	1.4%	0.7%	-4.9%	2.3%	2.2%	1.5%
Wales		2014	203,000	118,000	1,000	37,000	15,000	32,000
		2015	206,000	119,000	1,000	39,000	15,000	31,000
		Change	1.4%	1.5%	-13.6%	5.4%	2.9%	-3.7%
Scotland		2014	409,000	151,000	29,000	77,000	42,000	110,000
		2015	422,000	158,000	31,000	79,000	44,000	110,000
		Change	3.0%	4.5%	4.0%	1.9%	6.8%	0.0%
Northern Ireland		2014	120,000	64,000	1,000	28,000	11,000	15,000
		2015	119,000	64,000	1,000	29,000	11,000	15,000
		Change	-0.4%	-0.3%	9.0%	1.1%	-1.9%	-3.0%
UK total		2014	5,529,000	2,393,000	57,000	952,000	1,041,000	1,086,000
		2015	5,651,000	2,415,000	61,000	978,000	1,073,000	1,124,000
		Change	2.2%	0.9%	8.3%	2.7%	3.0%	3.5%
Share of total UK engineering enterprises turnover		2014	-	43.3%	1.0%	17.2%	18.8%	19.6%
		2015	-	42.7%	1.1%	17.3%	19.0%	19.9%
		Change	-	-0.5%	0.1%	0.1%	0.2%	0.2%

Source: IDBR

2.4 Economic value

2.4.1 Gross value added (GVA)

Analysis by the Centre for Economics and Business Research (Cebr) for Engineering UK suggests that the gross value added (GVA) for the UK by the engineering sector was £433 billion in 2015.[2.2] This was more than some key comparable sectors of the economy, including retail and wholesale, and financial and insurance (Table 2.11). The construction sector's contribution, for example, was estimated at £108 billion.

The GVA is a measure of the value in the national accounts of an activity. Essentially, it is the value of industrial output minus the value of the intermediate goods and services used as inputs to produce that activity. GVA will be distributed to employees, shareholders and to the government. It is linked as a measurement to GDP (GVA plus taxes, minus subsidies, equals GDP). Taxes and subsidies tend only to be valued at the whole economy level rather than by sector or region, so GVA is a useful measure of a sector or region's contribution to the economic picture.

From this GVA figure, it is estimated that the engineering sector's contribution to UK GDP in 2015 was £486 billion, which is around 26% of the total. This represents 2.3% growth since 2014 (the engineering sector GVA for 2014 has been revised since the 2016 edition of this publication).

Table 2.11: Comparison of GVA in the engineering footprint and other selected industrial sectors (2014-2015) – UK[2.3]

Industry	GVA (£ billion)	
	2014	2015
Engineering footprint sectors	423[2.4]	433
Retail and wholesale	187	193
Professional, scientific and technical activities	129	133
Financial & insurance	120	125
Construction	99	108

Source: Cebr analysis

In Table 2.12, the economic contribution of engineering sub-sectors has been estimated, using estimates of GVA contributions and employment numbers in industries within a selection of engineering-based SIC codes. The biggest contributor to the £433 billion total was electrical and electronic engineering, at almost £124 billion. This was followed by chemical, process and energy engineering at almost £79 billion. Manufacturing and general engineering groupings each contributed about £65 billion to the engineering total. The very small relative GVA contribution of civil engineering is thought to be due to the majority of the GVA in this area being reported under construction rather than engineering in the foregoing analysis.

Cebr has used Labour Force Survey estimates for the total employment figures within the engineering sector. These are close to the total of 5.7 million reported through employment records and used earlier in this chapter. On this basis, more than one million were employed in both the electrical and electronic engineering and manufacturing sectors.

Table 2.12: Breakdown of projected GVA and employment in engineering footprint sub-sectors (2015) – UK

Engineering sector	GVA (£ billion)	Employment (thousands)
Automotive engineering	18.4	357
General engineering	64.8	485
Civil engineering	1.5	318
Mechanical engineering	13.9	186
Aerospace engineering	17.2	92
Electronic and electrical engineering	123.8	1,648
Production and manufacturing engineering	65.2	1,017
Chemical, process and energy engineering	78.9	930
Other	49.2	788
Total	433.0	5,821

Source: Cebr analysis

2.2 Cebr: *An updated assessment of the economic contribution of engineering to the UK economy*, November 2016. 2.3 Cebr analysis using Annual Business Survey 2014, Business Register and Employment Survey 2014, Labour Force Survey indicators 2016. 2.4 Value revised since publication in Engineering UK 2016 publication

When this is analysed by UK nation and English region, London is revealed as the highest engineering contributor (over £94 billion, see Table 2.13). However, as a proportion of the total economic value of the region, its contribution was average, at 26%. Proportionally, engineering accounted for the largest percentage of the South East's regional GVA, at 34%. Its value was second only to London, at over £80 billion. Other regions where engineering made up around 30% of the economy were the North West, Northern Ireland (despite being the smallest numerically) and the East Midlands. As a proportion of the economy, engineering was weakest on this basis in Wales, despite comprising 22% of the nation's GVA.

On the basis of its figures for the extent of employment, together with HMRC records and national VAT returns, Cebr has estimated that the engineering sector contributed a total of £115 billion in taxes during 2015. This estimate included £31 billion of income tax and £21 billion national insurance from those who were in employment or self-employment in the sector, plus nearly £12 billion of corporation tax and £51 billion of indirect taxes such as VAT.

2.4.2 Multiplier effects

The engineering sector has wider impacts on the UK economy through its supply chain, within which there is further GVA based on the activity of those organisations and the people they employ. By estimating the value of these additional activities that are dependent on the engineering sector, it is possible to derive an overall estimate for the economic value of engineering's impact on the UK economy.

Table 2.14 illustrates Cebr's estimates on how the supply chain impacts on UK engineering activity. It shows that the largest component of the engineering sector's purchases are from within the engineering sector itself (42% of goods and services purchased). This can be understood through examples such as energy generation being dependent on mining and extraction, and in turn manufacturing being dependent on energy generation as well as raw materials from the mining and extraction sector. Imported goods and services represent around 29% of all purchased inputs, with a wide variety of other sectors contributing much smaller percentages. All of these industries are direct beneficiaries of increases in engineering activity, and so are seen as part of the multiplier impact of engineering.

From modelling based on these estimates, each £1 of GVA that is created directly by the engineering sector creates a further £0.83 through its indirect impact on the supply chain, together with additional induced impacts of £0.62. (Induced impacts are the effect of both direct and indirect impacts on household incomes, through increased employment returns. Some of this income is in turn spent on additional consumer goods and services, all of which have their own supply chains.) Together, this leads to a multiplier effect of 2.45 times the original direct GVA. For engineering to increase its supply, there are increased demands on those in the supply chain, who in turn place additional demands on their own supply chain, and so on.

If these effects are applied to the total engineering GVA estimate of £433 billion for 2015, a total impact of £1,061 billion is derived. This represents a total contribution to GDP of approximately £1,190 billion once the additional contributions to the economy of taxes on products are included.

A similar projection can be made in relation to employment, which suggest that there is a total multiplier effect of 2.74. In other words, for each additional person employed directly in the engineering sector and contributing direct GVA, there is an indirect impact on employment of a further 1.0 job in the supply chain sectors contributing to engineering, and a further 0.74 jobs in other sectors resulting from the additional induced impact. Based on an estimate for engineering sector employment of around 5.7 million, this leads to a projection that as many as 15.6 million people in the UK are supported by the activity of the engineering sector.

Table 2.13: GVA of the engineering footprint by region/nation (2015) – UK

Nation	Region	2015	
		GVA (£ billion)	Proportion of nation/region total
England		376.5	27.0%
	North East	11.0	23.6%
	North West	45.2	30.7%
	Yorkshire and The Humber	25.4	24.4%
	East Midlands	27.6	29.6%
	West Midlands	25.6	22.7%
	East	39.0	28.4%
	London	94.6	26.2%
	South East	80.6	34.0%
	South West	27.5	23.1%
Wales		11.5	21.9%
Scotland		35.0	25.8%
Northern Ireland		9.9	29.7%
UK total		433.0	26.5%

Source: Cebr analysis

Table 2.14: Estimated composition of supply chain to the engineering footprint, on the basis of purchased goods and services

Sector	Proportion of purchased intermediate inputs
Engineering footprint sectors	42.3%
Wholesale and retail	6.5%
Administrative and support services	4.5%
Financial and insurance services	4.0%
Transport and storage	2.5%
Construction	2.2%
Professional, scientific and technical	1.6%
Agriculture, forestry and fishing	1.4%
Public administration and defence	1.2%
Real estate	0.5%
Other manufacturing	0.2%
Other services	0.1%
Water and waste services	0.2%
Information and communications	0.1%
Accommodation and food services	0.1%
Human health and social work	0.1%
Imported goods and services	29.2%

Source: Cebr analysis

Part 1 – Engineering in Context
3 Demographics

Key points

Since the UK population will be an important source for UK engineering's future workforce, this chapter sets out some key demographic trends.

Population trends

The UK population is set to grow from its current 66 million by around 3% in the next five years and by 11% in the next twenty, potentially reaching 73 million by 2037.

Population growth has recently been – and is expected to continue to be – focused in London and South East England, with weaker growth in northern England, Wales and Scotland.

We are reaching the end of a period of decline in the number of young people aged 16-18 in the UK; this will bottom out in 2018 and then begin to rise quite quickly. For 21-year-olds and, for that matter, those approaching retirement age, the bottom of the trough will be a few years later.

The number of secondary school-aged children who are the focus of much of EngineeringUK's effort is already rising and will do so by 10% or more over the next five years. This provides an expanding school cohort to be encouraged to study subjects that could enable them to pursue engineering careers.

The male population will rise slightly more than the female population. The ethnicity profile of the population is less robustly modelled, but the proportion of those of ethnic minority background is expected to rise significantly from its current 13% across the UK. This proportion varies markedly by region and nation, from around 40% in London to under 2% in Northern Ireland. There is a very substantial concentration of those of ethnic minority background in our large cities.

Education

The number of schools is rising in response to these shifts in population, with some 3.8 million children currently educated in state-maintained secondary schools. A further 7% are educated in the independent sector (which educates 16% of those of sixth form age). While there has been a rise in the number of primary school teachers, this is not the case in the secondary sector, which is of concern.

The proportion of young adults entering higher education to study first degrees has reached record levels, with the focus on full-time study. The number of people studying part-time has fallen sharply in recent years, and the further education sector (where most part-time study is provided, and much vocational study) is weak and struggling.

The picture in terms of social mobility is very mixed: young people in London and its commuter belt are more likely to obtain good educational outcomes and have better career opportunities than those in the rest of the UK.

The UK workforce

Some 31.8 million people were employed in the UK in 2015: a record employment rate of over 74% nationally and higher still in the South East and Eastern England. Non-UK nationals accounted for 11% of all employed people. In the year to 2015, the non-UK workforce grew by 7.5% (compared with 1.5% growth in the UK workforce). This is largely attributable to immigration from European Union countries.

The engineering workforce is getting older, but not significantly faster than the UK workforce overall. However, the proportion of young workers (aged under 25, especially) has been decreasing over the last ten years.

The engineering workforce continues to be male-dominated. Women make-up one fifth of the engineering sector workforce but only one eighth of all those in engineering occupations, and under 10% of the core engineering workforce (those in an engineering role in an engineering company). The low proportion of women aged under 25 in the workforce means that the overwhelmingly male profile will not change soon organically.

3.1 Population trends

The size of the population is one of the most important factors affecting the potential supply of labour with engineering skills, including the 'pipeline' of students who can study for STEM qualifications and progress into engineering employment. Any strategic targets for STEM engagement, education provision, qualification attainment and business expansion must all take into account the simple fact that the population and key age cohorts undergo significant changes from year to year. This section describes the latest understanding of the UK's projected population at different ages, with a particular focus on young people.

Table 3.1 shows the most recent population projections for the UK over the next 20 years.[3.1] In total, the population is set to grow from its current 66 million by around 3% in the next five years and over 11% in the next 20 years. Potentially, it could reach over 73 million by 2037. This growth is expected to be slightly biased towards males.

3.1 National and regional population projections are based on the Office for National Statistics' principal projection method. An overview is available from the ONS: *National population projections QMI* (webpage). https://www.ons.gov.uk/peoplepopulationandcommunity/populationandmigration/populationprojections/qmis/nationalpopulationprojectionsqmi and *Subnational population projections QMI* (webpage). https://www.ons.gov.uk/peoplepopulationandcommunity/populationandmigration/populationprojections/qmis/subnationalpopulationprojectionsqmi

Table 3.1: National population projections by ages 7-21 and 65 (2017-2037) – UK

Age	2017	2022	2027	2032	2037	5 year percentage change (2017-2022)	20 year percentage change (2017-2037)
				Overall			
7	811,955	797,347	824,739	828,984	819,835	-1.8%	1.0%
8	803,511	803,882	823,155	832,563	822,855	0.0%	2.4%
9	809,294	824,227	820,530	834,937	826,267	1.8%	2.1%
10	782,325	850,438	816,653	835,719	829,996	8.7%	6.1%
11	766,236	838,556	812,493	835,434	834,453	9.4%	8.9%
12	736,601	822,564	807,476	834,878	839,142	11.7%	13.9%
13	723,764	814,267	814,191	833,480	842,902	12.5%	16.5%
14	703,448	820,279	834,784	831,114	845,538	16.6%	20.2%
15	693,354	794,044	861,726	827,979	847,066	14.5%	22.2%
16	713,307	779,106	851,013	824,997	847,959	9.2%	18.9%
17	734,088	751,143	836,676	821,650	849,066	2.3%	15.7%
18	761,288	742,033	832,069	832,045	851,362	-2.5%	11.8%
19	779,049	729,591	845,822	860,384	856,764	-6.3%	10.0%
20	812,448	729,399	829,335	897,049	863,391	-10.2%	6.3%
21	824,990	758,845	823,645	895,573	869,648	-8.0%	5.4%
65	672,482	734,696	847,783	882,399	840,619	9.3%	25.0%
All ages	66,029,928	68,202,846	70,234,132	72,053,345	73,672,863	3.3%	11.6%
				Male			
7	415,456	408,983	423,018	425,207	420,536	-1.6%	1.2%
8	411,103	412,744	422,234	427,069	422,109	0.4%	2.7%
9	414,300	423,292	420,895	428,288	423,860	2.2%	2.3%
10	400,960	436,058	418,912	428,690	425,776	8.8%	6.2%
11	392,000	429,796	416,800	428,563	428,074	9.6%	9.2%
12	377,034	420,940	414,229	428,268	430,466	11.6%	14.2%
13	370,561	416,660	418,067	427,567	432,410	12.4%	16.7%
14	360,487	420,055	428,821	426,438	433,840	16.5%	20.3%
15	355,257	407,257	442,128	425,005	434,794	14.6%	22.4%
16	364,786	399,111	436,688	423,722	435,498	9.4%	19.4%
17	377,308	385,302	428,981	422,309	436,357	2.1%	15.7%
18	390,968	380,937	426,784	428,222	437,745	-2.6%	12.0%
19	399,855	374,797	434,043	442,850	440,497	-6.3%	10.2%
20	417,063	374,502	426,107	461,002	443,937	-10.2%	6.4%
21	425,878	388,942	422,763	460,358	447,455	-8.7%	5.1%
65	327,136	358,303	413,024	429,168	408,815	9.5%	25.0%
All ages	32,583,656	33,756,729	34,839,116	35,805,632	36,671,657	3.6%	12.5%
				Female			
7	396,499	388,364	401,721	403,777	399,299	-2.1%	0.7%
8	392,408	391,138	400,921	405,494	400,746	-0.3%	2.1%
9	394,994	400,935	399,635	406,649	402,407	1.5%	1.9%
10	381,365	414,380	397,741	407,029	404,220	8.7%	6.0%
11	374,236	408,760	395,693	406,871	406,379	9.2%	8.6%
12	359,567	401,624	393,247	406,610	408,676	11.7%	13.7%
13	353,203	397,607	396,124	405,913	410,492	12.6%	16.2%
14	342,961	400,224	405,963	404,676	411,698	16.7%	20.0%
15	338,097	386,787	419,598	402,974	412,272	14.4%	21.9%
16	348,521	379,995	414,325	401,275	412,461	9.0%	18.3%
17	356,780	365,841	407,695	399,341	412,709	2.5%	15.7%
18	370,320	361,096	405,285	403,823	413,617	-2.5%	11.7%
19	379,194	354,794	411,779	417,534	416,267	-6.4%	9.8%
20	395,385	354,897	403,228	436,047	419,454	-10.2%	6.1%
21	399,112	369,903	400,882	435,215	422,193	-7.3%	5.8%
65	345,346	376,393	434,759	453,231	431,804	9.0%	25.0%
All ages	33,446,272	34,446,117	35,395,016	36,247,713	37,001,206	3.0%	10.6%

Source: ONS - (APS)[3.2]

Back to Contents

Table 3.2: National and regional total population projections in thousands – UK

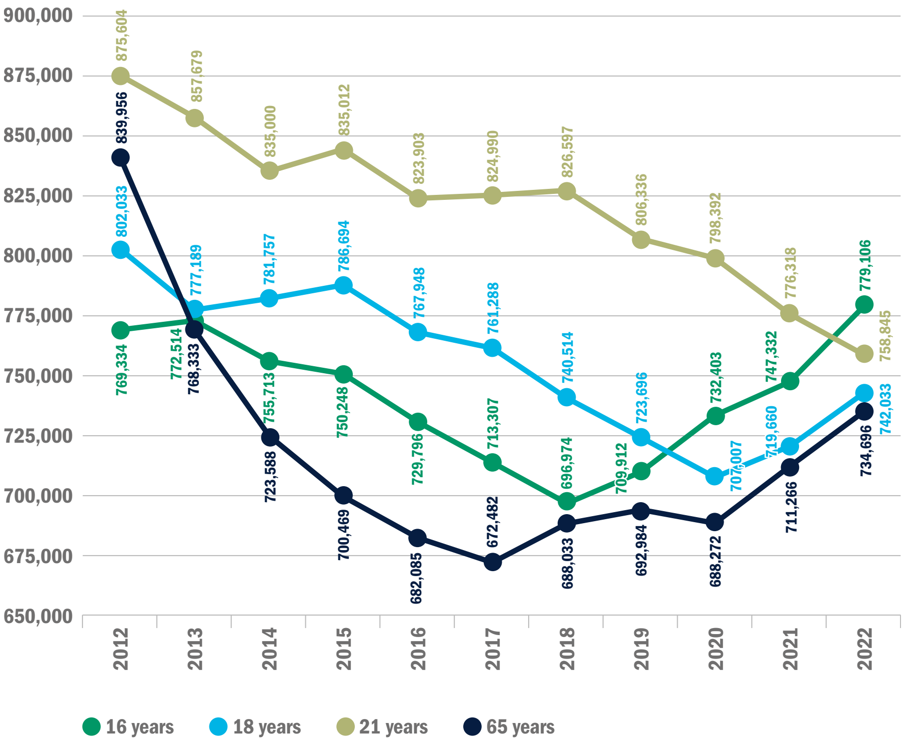
	2017	2018	2019	2020	2021	2022	2027	5 year change 2017-2022	10 year change 2017-2027
England	55,640	56,062	56,466	56,862	57,248	57,634	59,493	3.6%	6.9%
North East	2,645	2,653	2,661	2,669	2,677	2,684	2,725	1.5%	3.0%
North West	7,219	7,248	7,276	7,303	7,330	7,356	7,483	1.9%	3.7%
Yorkshire and The Humber	5,441	5,467	5,491	5,515	5,538	5,561	5,679	2.2%	4.4%
East Midlands	4,736	4,767	4,798	4,829	4,859	4,889	5,040	3.2%	6.4%
West Midlands	5,819	5,854	5,888	5,921	5,954	5,987	6,148	2.9%	5.6%
East	6,180	6,234	6,289	6,342	6,396	6,449	6,705	4.4%	8.5%
London	8,958	9,081	9,197	9,306	9,411	9,512	9,982	6.2%	11.4%
South East	9,098	9,171	9,243	9,314	9,385	9,455	9,800	3.9%	7.7%
South West	5,545	5,586	5,624	5,662	5,700	5,739	5,931	3.5%	7.0%
Wales	3,120	3,130	3,139	3,149	3,158	3,168	3,215	1.5%	3.0%
Scotland	5,396	5,412	5,428	5,445	5,462	5,480	5,565	1.6%	3.1%
Northern Ireland	1,874	1,884	1,894	1,904	1,913	1,922	1,961	2.6%	4.6%
UK	66,030	66,488	66,927	67,360	67,781	68,204	70,234	3.3%	6.4%

Source: ONS[3.3]

Looking at a somewhat shorter time horizon, but in more detail, Table 3.2 shows how this overall growth in population is expected to be seen by UK nation and English region. London and the South East, already with large populations, are expected to grow fastest, with over 6% growth in London by 2022 and 11% by 2027. In contrast, growth in the North East, North West and Scotland and Wales is expected to be less than 2% by 2022 and around 3% by 2027. These trends suggest an ever-greater focus of the population towards south eastern England and the capital.

On the other hand, there are different projected population trajectories for different age cohorts. To illustrate this, Figure 3.1 depicts the projected population trajectories for people of certain ages which relate to key points in education and work, for the ten-year period from 2012 to 2022. This shows that the UK is approaching the end of a period of decline in the number of 16-year-olds, with numbers expected to bottom out in 2018 before rising again quite quickly. For 18-year-olds, there is a similar pattern, although the low point is a year later, while for 21-year-olds, the decline continues beyond 2022 (but rises again subsequently, as shown in Table 3.1). Meanwhile, the population at 65 years (a typical retirement age) has been on quite a strongly falling trend since 2012 but will soon begin to rise again.

Figure 3.1: National population projections by ages 16, 18, 21 and 65 (2014-2022) – UK



Source: ONS - (APS)[3.4]

3.2 ONS: *National population projections, principal projection – UK, population single year of age, 2014-based.* https://www.ons.gov.uk/peoplepopulationandcommunity/populationandmigration/populationprojections **3.3** ONS: *National population projections*, principal projection – UK, population single year of age, 2014-based https://www.ons.gov.uk/peoplepopulationandcommunity/populationandmigration/populationprojections/bulletins/subnationalpopulationprojectionsforengland/2014basedprojections; ONS: *National population projections*, principal projection – Wales, population single year of age, 2014-based https://www.ons.gov.uk/peoplepopulationandcommunity/populationandmigration/populationprojections/datasets/z4zippedpopulationprojectionsdatafileswales; ONS: *National population projections*, principal projection – Scotland, population single year of age, 2014-based https://www.ons.gov.uk/peoplepopulationandcommunity/populationandmigration/populationprojections/datasets/z5zippedpopulationprojectionsdatafilesscotland; ONS: *National population projections*, principal projection – Northern Ireland, population single year of age, 2014-based https://www.ons.gov.uk/peoplepopulationandcommunity/populationandmigration/populationprojections/datasets/z6zippedpopulationprojectionsdatafilesextravariantsnorthernireland **3.4** ONS: *National population projections*, principal projection – UK, population single year of age, 2014-based https://www.ons.gov.uk/peoplepopulationandcommunity/populationandmigration/populationprojections

The 11- to 14-year-old age groups have been identified as key for interventions that stimulate interest in STEM progression, and so are worth focusing on. Tables 3.3 to 3.6 show the projected populations at these ages for the next ten years, including annually through to 2022. These tables are interesting for the different base numbers in the English regions, as well as the projected trends. For example, for 11-year-olds, growth is strongest in England, but this is driven by particularly strong expected increases in London, the East of England and, to a somewhat lesser extent, other parts of southern England, which are already some of the most populated areas (Table 3.3). Meanwhile, very little growth is expected in the North East, Yorkshire and the Humber, the North West, and especially Wales.

For 12-year-olds, the pattern is broadly similar but with stronger growth during 2017 to 2022, which is expected to be more widely distributed across the UK. Some modest declines expected for this age group between 2022 and 2027 will then reduce the overall extent of growth (Table 3.4). The picture is somewhat similar for 13-year-olds, with stronger growth across the board through to 2022 but then a slow-down and some decline through to 2027 (Table 3.5). Projected growth is strongest of all for 14-year-olds, with double digit expansion in all regions and Northern Ireland by 2017, and an increase of up to 27% by 2027 (Table 3.6).

Table 3.3: Projected population of 11-year-olds by region/nation (2017-2027) – UK

Nation	Region	2017	2018	2019	2020	2021	2022	2027	5 year change 2017-2022	10 year change 2017-2027
England		651,216	666,823	690,700	687,232	698,807	712,872	752,637	9.5%	15.6%
	North East	29,796	29,572	30,789	30,296	31,124	31,612	29,788	6.1%	0.0%
	North West	85,089	86,309	89,153	87,976	89,025	90,946	87,465	6.9%	2.8%
	Yorkshire and The Humber	64,359	65,018	66,947	67,217	67,945	68,039	65,461	5.7%	1.7%
	East Midlands	54,775	55,644	57,888	57,259	58,266	59,695	57,802	9.0%	5.5%
	West Midlands	70,449	71,747	74,226	73,775	73,901	75,631	73,800	7.4%	4.8%
	East	72,359	74,390	77,902	78,168	79,468	81,192	79,765	12.2%	10.2%
	London	105,323	109,758	113,484	112,926	115,031	117,745	119,397	11.8%	13.4%
	South East	108,600	111,877	115,763	115,372	118,347	120,732	116,403	11.2%	7.2%
	South West	60,466	62,508	64,548	64,243	65,700	67,280	65,553	11.3%	8.4%
Wales		35,426	36,391	36,545	36,826	37,394	37,483	34,942	5.8%	-1.4%
Scotland		56,855	58,881	60,270	59,547	60,227	60,904	57,442	7.1%	1.0%
Northern Ireland		23,991	25,283	25,846	25,856	25,788	25,936	24,858	8.1%	3.6%
UK		767,488	787,378	813,361	809,461	822,216	837,195	869,879	9.1%	13.3%

Source: ONS[3.3]

Table 3.4: Projected population of 12-year-olds by region/nation (2017-2027) – UK

Nation	Region	2017	2018	2019	2020	2021	2022	2027	5 year change 2017-2022	10 year change 2017-2027
England		623,817	653,442	668,885	692,703	689,185	700,760	690,273	12.3%	10.7%
	North East	28,092	29,844	29,623	30,836	30,345	31,169	29,614	11.0%	5.4%
	North West	81,725	85,285	86,496	89,338	88,162	89,213	86,973	9.2%	6.4%
	Yorkshire and The Humber	61,664	64,454	65,107	67,036	67,296	68,028	65,076	10.3%	5.5%
	East Midlands	52,063	55,084	55,954	58,196	57,572	58,579	57,492	12.5%	10.4%
	West Midlands	68,715	70,659	71,949	74,425	73,970	74,106	73,082	7.8%	6.4%
	East	69,554	72,750	74,775	78,277	78,529	79,834	79,180	14.8%	13.8%
	London	99,824	104,931	109,236	112,904	112,330	114,411	117,299	14.6%	17.5%
	South East	103,773	109,406	112,679	116,573	116,174	119,152	116,170	14.8%	11.9%
	South West	58,407	61,029	63,066	65,118	64,807	66,268	65,387	13.5%	12.0%
Wales		34,409	35,526	36,491	36,646	36,926	37,494	34,880	9.0%	1.4%
Scotland		56,417	56,915	58,942	60,333	59,613	60,293	57,524	6.9%	2.0%
Northern Ireland		23,245	24,041	25,332	25,893	25,902	25,833	24,884	11.1%	7.1%
UK		737,888	769,924	789,650	815,575	811,626	824,380	807,561	11.7%	9.4%

Source: ONS[3.3]

Back to Contents

Table 3.5: Projected population of 13-year-olds by region/nation (2017-2027) – UK

Nation	Region	2017	2018	2019	2020	2021	2022	2027	5 year change 2017-2022	10 year change 2017-2027
England		613,192	626,042	655,508	670,896	694,665	691,148	695,998	12.7%	13.5%
	North East	27,618	28,133	29,877	29,660	30,871	30,383	29,888	10.0%	8.2%
	North West	79,731	81,902	85,454	86,663	89,503	88,332	88,857	10.8%	11.4%
	Yorkshire and The Humber	60,319	61,750	64,533	65,184	67,116	67,368	66,388	11.7%	10.1%
	East Midlands	51,908	52,341	55,349	56,228	58,467	57,849	57,784	11.4%	11.3%
	West Midlands	67,316	68,924	70,869	72,157	74,633	74,176	74,475	10.2%	10.6%
	East	69,278	69,929	73,122	75,150	78,643	78,888	80,108	13.9%	15.6%
	London	95,746	99,688	104,689	108,917	112,536	111,966	115,955	16.9%	21.1%
	South East	103,423	104,443	110,056	113,337	117,234	116,835	116,611	13.0%	12.8%
	South West	57,853	58,932	61,559	63,600	65,662	65,351	65,932	13.0%	14.0%
Wales		33,530	34,494	35,611	36,576	36,730	37,011	35,114	10.4%	4.7%
Scotland		55,501	56,474	56,974	59,001	60,394	59,673	57,777	7.5%	4.1%
Northern Ireland		22,746	23,294	24,088	25,379	25,939	25,948	25,015	14.1%	10.0%
UK		724,969	740,304	772,181	791,852	817,728	813,780	813,904	12.3%	12.3%

Source: ONS[3.3]

Table 3.6: Projected population of 14-year-olds by region/nation (2017-2027) – UK

Nation	Region	2017	2018	2019	2020	2021	2022	2027	5 year change 2017-2022	10 year change 2017-2027
England		595,660	615,418	628,123	657,534	672,873	696,640	714,169	17.0%	19.9%
	North East	26,911	27,655	28,168	29,906	29,696	30,904	30,778	14.8%	14.4%
	North West	77,369	79,938	82,095	85,649	86,858	89,701	90,561	15.9%	17.1%
	Yorkshire and The Humber	58,459	60,433	61,852	64,635	65,287	67,224	67,995	15.0%	16.3%
	East Midlands	50,220	52,194	52,630	55,632	56,521	58,760	59,601	17.0%	18.7%
	West Midlands	65,195	67,543	69,142	71,101	72,387	74,866	76,662	14.8%	17.6%
	East	66,551	69,588	70,239	73,437	75,468	78,954	81,942	18.6%	23.1%
	London	93,581	95,655	99,485	104,415	108,563	112,155	118,663	19.8%	26.8%
	South East	100,107	103,924	104,949	110,550	113,835	117,737	119,837	17.6%	19.7%
	South West	57,267	58,488	59,563	62,209	64,258	66,339	68,130	15.8%	19.0%
Wales		32,891	33,604	34,567	35,684	36,646	36,802	35,600	11.9%	8.2%
Scotland		53,724	55,565	56,539	57,040	59,069	60,459	58,289	12.5%	8.5%
Northern Ireland		22,257	22,797	23,344	24,137	25,426	25,990	25,212	16.8%	13.3%
UK		704,532	727,384	742,573	774,395	794,014	819,891	833,270	16.4%	18.3%

Source: ONS[3.3]

3.1.1 Ethnicity

The previous section showed that the UK population is expected to rise in coming years, and the population of young people will shortly recover after a recent period of decline. Projections also show that the total population will rise slightly more for males than females. Table 3.7 shows how the UK population was composed in terms of its ethnic background according to the 2011 Census (broken down by nation and region). Numerous models exist for projections of future population change in relation to ethnicity so, for the purposes of brevity, it is preferred here to use known Census data, and only to consider broad variances based on those data.

Where ethnicity is known, Table 3.7 shows that in 2011 White British remained by far the dominant major ethnic group numerically in all nations and regions, with 87.2% of the UK population. However, some regions have significantly greater percentages of minority ethnic groups than others. The national average is influenced heavily by London, which is considerably more ethnically-diverse than anywhere else. London had a white British population of just 59.8% in 2011, with significant percentages of Asian or Asian British (18.5%) and also Black, African, Caribbean or black British (13.3%). The West Midlands was next in terms of ethnic diversity, with 82.7% white, 10.8% Asian or Asian British and 3.3% Black, African, Caribbean or black British. This contrasts with the North East, South West, Wales, Scotland and North Northern Ireland where over 95% of the population were White. In Northern Ireland, that proportion was over 98%. This imbalance towards large urban concentration of the UK's non-white population has been highlighted by Policy Exchange, which states that, "just three cities (London, Greater Birmingham and Greater Manchester) account for over 50% of the UK's entire BME (black and minority ethnic) population."[3.5] The report also claimed that, "8 million people or 14% of the UK population belong to an ethnic minority," while, "the 5 largest distinct minority communities are (in order of size): Indian, Pakistani, black African, black Caribbean and Bangladeshi."[3.6]

However, this picture is due to change significantly, although different models result in a range of possible distributions. What is common to them is that the proportion of British people who are not white is expected to increase significantly. It has been noted that ethnic minorities represent just 5% of the population aged over 60, but 25% of those aged under 5 years. This could mean that by 2051, BME communities will represent 20-30% of the UK's population.[3.14]

Based on the 2011 census data, Table 3.8 shows that 85.4% of England's total population were White British, but only 81.7% of 15- to 19-year-olds and 80.4% of 10- to 14-year-olds. The difference was accounted for by greater proportions of people from Black, African, Caribbean and black British, Asian and British

Table 3.7: Populations by broad ethnic group, by region/nation (2011) – UK[3.7]

		All	White[3.8]		Mixed / multiple ethnic group[3.9]		Asian / Asian British[3.10]		Black / African / Caribbean / black British[3.11]		Other ethnic group[3.12]	
Nation	**Region**		**Number**	**Percentage**	**Number**	**Percentage**	**Number**	**Percentage**	**Number**	**Percentage**	**Number**	**Percentage**
England		53,012,456	45,281,142	85.4%	1,192,879	2.3%	4,143,403	7.8%	1,846,614	3.5%	548,418	1.0%
	North East	2,596,886	2,475,567	95.3%	22,449	0.9%	74,599	2.9%	13,220	0.5%	11,051	0.4%
	North West	7,052,177	6,361,716	90.2%	110,891	1.6%	437,485	6.2%	97,869	1.4%	44,216	0.6%
	Yorkshire and The Humber	5,283,733	4,691,956	88.8%	84,558	1.6%	385,964	7.3%	80,345	1.5%	40,910	0.8%
	East Midlands	4,533,222	4,046,356	89.3%	86,224	1.9%	293,423	6.5%	81,484	1.8%	25,735	0.6%
	West Midlands	5,601,847	4,633,669	82.7%	131,714	2.4%	604,435	10.8%	182,125	3.3%	49,904	0.9%
	East of England	5,846,965	5,310,194	90.8%	112,116	1.9%	278,372	4.8%	117,442	2.0%	28,841	0.5%
	London	8,173,941	4,887,435	59.8%	405,279	5.0%	1,511,546	18.5%	1,088,640	13.3%	281,041	3.4%
	South East	8,634,750	7,827,820	90.7%	167,764	1.9%	452,042	5.2%	136,013	1.6%	51,111	0.6%
	South West	5,288,935	5,046,429	95.4%	71,884	1.4%	105,537	2.0%	49,476	0.9%	15,609	0.3%
Wales		3,063,456	2,928,253	95.6%	31,521	1.0%	70,128	2.3%	18,276	0.6%	15,278	0.5%
Scotland		5,295,403	5,084,407	96.0%	19,815	0.4%	140,678	2.7%	36,178	0.7%	14,325	0.3%
Northern Ireland		1,810,863	1,779,750	98.3%	6,014	0.3%	19,130	1.1%	3,616	0.2%	2,353	0.1%
UK		63,182,178	55,073,552	87.2%	1,250,229	2.0%	4,373,339	6.9%	1,904,684	3.0%	580,374	0.9%

Source: ONS[3.13]

3.5 Policy Exchange: *A portrait of modern Britain*, 2014, p7. http://www.policyexchange.org.uk/images/publications/a%20portrait%20of%20modern%20britain.pdf **3.6** Policy Exchange: *ibid* **3.7** Categories are those used by the ONS at top-line UK harmonised level. For further information see ONS: *Harmonised concepts and questions for social data sources: primary principles – ethnic group*, May 2015 http://www.ons.gov.uk/ons/guide-method/harmonisation/primary-set-of-harmonised-concepts-and-questions/ethnic-group.pdf **3.8** Includes: England and Wales – 'White: English/Welsh/Scottish/Northern Irish/British', 'White: Irish', 'White: other white' and 'White: gypsy or Irish traveller'; Scotland – 'White: Scottish', 'White: other British', 'White: Irish', 'White: Polish', 'White: other white' and 'White: gypsy/traveller'; Northern Ireland – 'White' and 'Irish traveller' **3.9** Includes: England and Wales – 'Mixed/multiple ethnic group: white and black Caribbean', 'Mixed/multiple ethnic group: white and black African', 'Mixed/multiple ethnic group: white and Asian' and 'Mixed/multiple ethnic group: other mixed'; Scotland – 'Mixed or multiple ethnic groups'; Northern Ireland – 'Mixed' **3.10** Includes: England and Wales – 'Asian/Asian British: Indian', Asian/Asian British: Pakistani', 'Asian/Asian British: Bangladeshi', 'Asian/Asian British: Chinese' and 'Asian/Asian British: other Asian'; Scotland – 'Asian, Asian Scottish or Asian British: Indian, Indian Scottish or Indian British', 'Asian, Asian Scottish or Asian British: Pakistani, Pakistani Scottish or Pakistani British', 'Asian, Asian Scottish or Asian British: Bangladeshi, Bangladeshi Scottish or Bangladeshi British', 'Asian, Asian Scottish or Asian British: Chinese, Chinese Scottish or Chinese British' and 'Asian, Asian Scottish or Asian British: other Asian'; Northern Ireland – 'Indian', 'Pakistani', 'Bangladeshi', 'Chinese' and 'Other Asian' **3.11** Includes: England and Wales – 'Black/African/Caribbean/black British: African', 'Black/African/Caribbean/black British: Caribbean' and 'Black/African/Caribbean/black British: other Black'; Scotland – 'African: African, African Scottish or African British', 'African: other African', 'Caribbean or black: Caribbean Scottish or Caribbean British', 'Caribbean or black: black, black Scottish or black British' and 'Caribbean or black: other Caribbean or black'; Northern Ireland – 'Black African', 'Black Caribbean' and 'Black other' **3.12** Includes: England and Wales – 'Other ethnic group: Arab' and 'Other ethnic group: any other ethnic group'; Scotland – 'Other ethnic groups: Arab, Arab Scottish or Arab British' and 'Other ethnic groups: other ethnic group'; Northern Ireland – 'Other' **3.13** *2011 Census, key statistics and quick statistics for local authorities in the United Kingdom – part 1*, October 2013, Workbook: 2011 Census: KS201UK Ethnic group, local authorities in the United Kingdom, Table: KS201UK_Numbers; http://www.ons.gov.uk/ons/rel/census/2011-census/key-statistics-and-quick-statistics-for-local-authorities-in-the-united-kingdom---part-1/rft-ks201uk.xls **3.14** Policy Exchange: *ibid.*

Asian, and especially mixed or multiple ethnic backgrounds. The proportion of this last grouping amongst 10- to 14-year-olds was almost twice as high as in the overall population.

In contrast, the differences in proportions between white and ethnic minority backgrounds among the general population and young people vary much less in Wales, and even less so in Scotland and Northern Ireland. However, the trends for mixed and multiple ethnic backgrounds were are seen in all the nations.

3.2 Education

Engaging young people in STEM requires focused activities delivered through schools and colleges. Therefore, it is valuable to understand the broad trends of change within the UK education system in terms of numbers of establishments and pupils.

3.2.1 Schools, pupils and teachers

In the last academic year, there were 4,169 state-maintained secondary schools in the UK (a net increase of 11 on the previous year), along with almost 21,000 maintained primary schools (Table 3.9). Whilst many of the secondary schools offer their own post-16 provision, there are also 90 designated sixth form colleges, and some pupils move to further education colleges for their post-16 education. Broadly, the number of maintained schools is rising in England, with much of the growth focused on regions with growth populations, such as London and the South East. In the other UK nations, however, school numbers are falling. There are also 2,449 independent schools, many of which cater for a wide range of pupil ages.

Table 3.8: Population by young age group and broad ethnic group (2011) – England[3.15]

	Total population	Percentage of total population	Number of 10- to 14-year-olds	Percentage of 10-14 age group	Number of 15- to 19-year-olds	Percentage of 15-19 age group
All categories	53,012,456	100.0%	3,080,929	100.0%	3,340,265	100.0%
White	45,281,142	85.4%	2,477,722	80.4%	2,729,955	81.7%
Mixed / multiple ethnic group	1,192,879	2.3%	138,048	4.5%	126,931	3.8%
Asian / Asian British	4,143,403	7.8%	286,140	9.3%	301,350	9.0%
Black / African / Caribbean / black British	1,846,614	3.5%	144,439	4.7%	144,245	4.3%
Other ethnic group	548,418	1.0%	34,580	1.1%	37,784	1.1%

Source: ONS,[3.16] NRS,[3.17] NIS and Research Agency[3.18]

Table 3.9: Primary, secondary and independent schools by region/nation (2015 or 2016) – UK

Nation	Region	State-funded primary	State-funded secondary	Independent
England (January 2016)		16,778	3,401	2,297
	North East	865	185	41
	North West	2,447	461	242
	Yorkshire and The Humber	1,787	313	139
	East Midlands	1,634	293	154
	West Midlands	1,776	418	208
	East of England	1,991	399	234
	London	1,813	484	537
	South East	2,600	503	529
	South West	1,865	345	213
Wales (January 2016)		1,310	205	66
Scotland (December 2015)		2,039	361	72
Northern Ireland (2015/16)		827	202	14
UK total		20,954	4,169	2,449

Source: DfE,[3.19] StatsWales,[3.20] Scottish Government,[3.21] Scottish Council of Independent Schools and Department of Education Northern Ireland[3.22]
Note: Excludes special schools, hospital schools and pupil referral units

3.15 See Table 3.7 footnotes for categories included in each broad ethnic grouping **3.16** *2011 Census: DC2101EW – Ethnic group by sex by age – England*: https://www.nomisweb.co.uk/census/2011/DC2101EW/view/2092957699?rows=c_age&cols=c_ethpuk11; 2011 *Census: DC2101EW – Ethnic group by sex by age – Wales*: https://www.nomisweb.co.uk/census/2011/DC2101EW/view/2092957700?rows=c_age&cols=c_ethpuk11 **3.17** National Records of Scotland: *Scotland's Census 2011: DC2101SC – Ethnic group by sex by age*. http://www.scotlandscensus.gov.uk/ods-web/standard-outputs.html **3.18** Northern Ireland Statistics and Research Agency: *Census 2011: Ethnic Group by Age by Sex DC2101NI* (administrative geographies): Northern Ireland Neighbourhood Information Service, November 2013, Folder: NI, Workbook: DC2101NI; http://www.ninis2.nisra.gov.uk/Download/Census%202011_Winzip/2011/DC2101NI%20(a).zip **3.19** DfE: *Schools, pupils and their characteristics*, January 2016 – Local authority and regional tables: SFR20_2016, June 2016, Table 7a; https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/532038/SFR20_2016_National_Tables.xlsx **3.20** StatsWales [Welsh government]: *Pupil level annual school census* (PLASC), January 2016, July 2016, Table: Schools by local authority, region and type of school; https://statswales.gov.wales/Catalogue/Education-and-Skills/Schools-and-Teachers/Schools-Census/Pupil-Level-Annual-School-Census/Schools/schools-by-localauthorityregion-type; StatsWales [Welsh Government]: *Pupil Level Annual School Census* (PLASC): January 2016, July 2016, Table: Schools by local authority, region and year; https://statswales.wales.gov.uk/Catalogue/Education-and-Skills/Schools-and-Teachers/Schools-Census/Independent-Schools/Schools/schools-by-localauthorityregion-year **3.21** Scottish government: *Summary statistics for schools in Scotland*, December 2015 http://www.gov.scot/Publications/2015/12/7925 **3.22** Scottish Council of Independent Schools: *Facts & Figures: Facts and statistics about independent schools in Scotland*, 2015, http://www.scis.org.uk/facts-and-figures; Education Northern Ireland: *Annual enrolments at schools and in funded pre-school education in Northern Ireland*, 2015/16, July 2016, https://www.education-ni.gov.uk/sites/default/files/publications/education/Statistical%20Bulletin%201516%20-%20March%20(20.07.16%20update).PDF

In these 4,169 state-maintained secondary schools, there were almost 3.8 million pupils (Table 3.10). This number is slightly up on the previous year – despite downward trends in the populations of children at some of the relevant ages – which could reflect the impact of recent immigration. Just under 3.2 million pupils were in England, giving an average of about 939 pupils per school in 2015/16. This is higher than the average for the UK as a whole, because schools in the other nations tend to be smaller (with averages of 872 students per school in Wales, 781 in Scotland and 699 in Northern Ireland). No comparable figure is available for the independent sector as the number of independent schools combines schools at all educational stages. However, it is known that around 7% of pupils in England are educated in the independent sector, rising to 16% for sixth form study. It is lower at around 4% in Scotland.

As might be expected, comparison with the previous year's pupil numbers reflects the pattern of slight population shift: there were around 10,000 more pupils in England than the year before, but fewer in the other nations, with very slight reductions in some regions of England, and significant growth in London.

The average secondary class size in England, as reported by the Department for Education, was 20.4;[3.26] directly comparable figures for the devolved nations are not readily available. Trends in the number of teachers in the maintained (state) sector are considered in more detail in Chapter 5, but broadly show that there has recently been a rise in the number of primary teachers but a continued fall in the number of secondary teachers. However, following several years of devolved education policy, it is increasingly hard to keep robust track of some of this data, as it is not always treated consistently in the different UK nations.

Historically, one of the most widely used measures of deprivation for young people has been the provision of free school meals (FSM). This is because eligibility is means-tested, so the number and percentage of pupils eligible has been analysed regularly. However, recent policy changes in this area have included extension of FSM provision to all infant-stage pupils in English primary schools from 2014 and to all primary 1-3 pupils in Scotland in 2015. This means that FSM provision in primary schools can no longer simply be considered as a measure of deprivation.

Table 3.10: Primary and secondary pupils by region/nation (2015 or 2016) – UK[3.23]

Nation	Region	State-funded primary	State-funded secondary	Independent
England (January 2016)		4,615,172	3,193,418	583,030
	North East	221,004	155,139	10,360
	North West	638,144	412,375	46,190
	Yorkshire and The Humber	484,690	317,173	31,812
	East Midlands	393,059	277,659	30,911
	West Midlands	512,265	357,177	43,842
	East of England	503,492	370,759	67,355
	London	744,906	492,353	148,011
	South East	710,569	500,263	149,879
	South West	407,043	310,520	54,670
Wales (January 2016)		276,954	178,669	8,880
Scotland (December 2015)		391,148	281,939	30,238
Northern Ireland (2015/16)		168,910	141,112	658
UK total		5,452,184	3,795,138	622,806

Source: DfE, Scottish Government, Scottish Council of Independent Schools, Department of Education Northern Ireland;[3.24] StatsWales[3.25]

Table 3.11: Number and percentage of pupils in maintained secondary schools eligible for free school meals by region/nation (2015 or 2016) – UK

Nation	Region	Number of pupils known to be eligible for and claiming free school meals	Percentage known to be eligible for and claiming free school meals
England (January 2016)		389,359	14.1%
	North East	24,194	17.7%
	North West	59,824	16.1%
	Yorkshire and The Humber	43,153	15.5%
	East Midlands	30,125	12.6%
	West Midlands	51,530	16.5%
	East of England	32,565	10.3%
	London	78,215	19.2%
	South East	39,977	9.3%
	South West	29,776	11.2%
Wales (January 2016)		27,943	15.6%
Scotland (February/March 2015)		39,280	14.2%
Northern Ireland (October 2014)		39,801	28.2%

Source: DfE,[3.27] StatsWales,[3.28] Scottish Government[3.29] and Department of Education Northern Ireland[3.30]

3.23 Categories of schools used are as stated in footnotes to Table 3.9 **3.24** England, Scotland and Northern Ireland sources: see Table 3.9 **3.25** StatsWales [Welsh Government]: *Pupil Level Annual School Census* (PLASC): January 2016, July 2016, Table: Pupils by local authority, region and age group. https://statswales.gov.wales/Catalogue/Education-and-Skills/Schools-and-Teachers/Schools-Census/Pupil-Level-Annual-School-Census/Pupils/pupils-by-localauthorityregion-agegroup; StatsWales [Welsh Government] : *Pupil Level Annual School Census* (PLASC): January 2016, July 2016. https://statswales.gov.wales/Catalogue/Education-and-Skills/Schools-and-Teachers/Schools-Census/Independent-Schools/Pupils/number-by-localauthorityregion **3.26** DfE: *Schools, pupils and their characteristics: January 2016 – National tables: SFR20/2016*, June 2016, Table 6b. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/433685/SFR16_2015_national_tables.xlsx **3.27** Department for Education: *Schools, pupils and their characteristics: January 2016 – National Tables*, SFR20/2016, June 2016. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/532643/SFR20_2016_Main_Text.pdf
3.28 Knowledge and Analytical Services [Welsh Government]: *School census results, 2016 – first release*, July 2016. http://gov.wales/docs/statistics/2016/160727-school-census-results-2016-en.pdf
3.29 Scottish government: *Healthy living survey 2016: schools meals and PE, supplementary data*, June 2016, Table 1. http://www.gov.scot/Resource/0050/00501861.xlsx **3.30** Department of Education Northern Ireland: *School meals – 2015/16 statistical bulletin*, April 2016. https://www.education-ni.gov.uk/publications/school-meals-201516-statistical-bulletin-14-april-2016

At secondary level, the number and proportion of pupils eligible for FSM in maintained schools is shown in Table 3.11. Proportions range quite widely, from 9.3% in the South East to 19.2% in London, with a national average for England of 14.1%. The figures give a further indication that in England there are greater levels of deprivation in the North East, the West Midlands and the North West, while London has the greatest overall affluence and yet the highest level of deprivation simultaneously. Although the number of eligible pupils was lower in every region compared with the previous year, overall and outside London, these changes actually represented slight rises proportionally. The proportion in Scotland was very similar to England, somewhat higher in Wales (15.6%), and considerably higher in Northern Ireland (28.2%). The latter saw a rise in both number and proportion compared with the previous year.

Table 3.12: Further education colleges by nation – UK

		2013	2014	2015	2016
England		341	339	335	325
	General FE colleges	219	218	216	209
	Sixth form colleges	94	93	93	90
	Land-based colleges	15	15	14	14
	Art, design and performing arts colleges	3	3	2	2
	Specialist designated colleges	10	10	10	10
Scotland		36	30	26	26
Wales		19	16	15	14
Northern Ireland		6	6	6	6
UK total		402	391	382	371

Source: AoC[3.31]

3.2.2 Further education

There are currently 371 further education colleges in the UK (Table 3.12), a number that has been in decline in recent years. Between 2013 and 2016, college numbers dropped by 8%, although this partly results from a number of mergers between institutions. Scotland, in particular, has seen a marked decline in its number of FE colleges.

The Association of Colleges (AoC) states that 2.9 million people are educated or trained in FE colleges annually and that more 16- to 18-year-olds (773,000) study in colleges than in school sixth forms (around 442,000). These figures for FE colleges do, however, include sixth form colleges. This provision represents around 27% of full-time A level students aged 16-18, and UCAS reports that 31% of students aged under 19 entering higher education have studied at an FE college.

Notably, the headline student numbers are lower than in comparable reports last year (when the total was 3.1 million students). This reflects the current decline in the FE sector (which is described further in Chapter 6). The AoC also reports that every FE college offers training for apprentices and that 297,000 people are currently on apprenticeship programmes, including about half of all apprentices in construction, engineering and manufacturing. FE colleges also deliver higher education, including over 80% of HNC and HND courses and over half of all foundation degrees.

3.2.3 Higher education

The broad shape of UK higher education in the completed 2014/15 academic year was of over 2.25 million students at 163 universities. Of these, around two thirds were studying for first degrees and a further 10% for other undergraduate programmes, together with 19% studying for postgraduate taught qualifications and 5% on postgraduate research programmes. The majority of students – just under 1.7 million – studied full-time (including 88% of those studying first degree programmes). However, this proportion varies strongly at different levels of study: part-time study is more common amongst postgraduates and those studying undergraduate programmes other than first degrees. Key recent trends, highlighted in Chapter 7, are that there has been strong growth in participation of first degree programmes by UK students, and growth in postgraduate programmes, greatly fuelled by international students.

The proportion of the UK's young people that goes to university has grown to record levels, while the number of universities is also generally increasing. However, this is more through redefinition of what constitutes a university than expansion of the number of institutions delivering HE, as the rules are being relaxed in terms of the extent of provision required and other factors in eligibility. The extent of private provision is also increasing as current government policy advocates greater competition in the sector, partly through opening it up to a wider range of providers. A full examination of the UK higher education scene, especially relating to engineering and STEM subjects, is given in Chapter 7.

3.2.4 Social mobility

There has been much research into the extent to which UK policies to expand participation in higher education have improved outcomes for all young people, by widening the social footprint of those who go to university. This tends to be measured in terms of participation by region or more local geography, such as postcode. However, participation in HE is only one measure of potential positive life outcomes. In an alternative approach, the Social Mobility and Child Poverty Commission developed its Social Mobility Index for England.[3.32] This examines the chances that a child from a disadvantaged background has to do well at school and get a good job compared with other children, and has been modelled for all 324 local authorities in England. The index considers the educational attainment of those from poorer backgrounds in each local area, for early years, primary and secondary school, through to post-16 outcomes and HE participation. This reflects the academic literature that suggests that educational attainment is a key driver of a child's life chances. It also considers outcomes achieved by adults in the area – average income, prevalence of low-paid work, availability of professional-level jobs, home ownership and housing affordability; these are all part of the prospects people have of converting good educational attainment into good life outcomes.

The results show substantial differences between different parts of the country. They also show that quite similar areas can perform quite differently against the index, which should mean that there is potential to improve the

3.31 AoC: *Key further education statistics* (webpage). https://www.aoc.co.uk/about-colleges/research-and-stats/key-further-education-statistics **3.32** Social Mobility & Child Poverty Commission: *The social mobility index*, January 2016. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/496103/Social_Mobility_Index.pdf performance of many currently low-performing areas. Key findings in the report include the following:

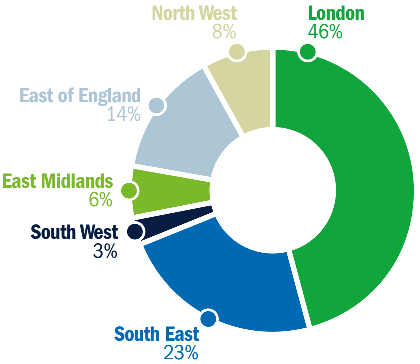
- London and its commuter belt are pulling away from the rest of England. Young people from disadvantaged backgrounds who live in these areas are far more likely to achieve good outcomes in school and have more opportunities to do well as adults than those in the rest of the country;
- Many coastal areas and industrial towns are becoming social mobility 'coldspots' as they perform badly on both educational measures and adulthood outcomes;
- Other than London, England's major cities are not necessarily the places of opportunity that they should be. None of the other major English cities perform well in the index, cities including Manchester, Birmingham and Southampton have average performance, while others, including Nottingham, Derby and Norwich, perform badly;
- Many of the richest places in England do worse for their disadvantaged children than places that are ostensibly much poorer. While there is a link between the overall affluence of a local area and the life chances of disadvantaged young people, many affluent areas fail young people from poor backgrounds;
- There is also great heterogeneity – similar areas only a few miles apart perform very differently on social mobility, despite having similar challenges and opportunities.

London does exceptionally well against the Social Mobility Index. Of the 32 London boroughs, 23 are in the top 10% of areas, and 30 are considered social mobility 'hotspots' (comprising 46% of the top quintile in the Index, as Figure 3.2 shows). This 'London effect' extends to much of the Home Counties. London, the South East and the East of England dominate, while all the other regions are significantly under-represented in terms of social mobility hotspots. Three regions – Yorkshire and the Humber, the North East and the West Midlands – have none at all.

Of more concern, perhaps, are the coldspots – the worst performing 20% of local areas in the index. More than four in ten local areas in the East Midlands and the West Midlands are identified as social mobility coldspots, and nearly as many in Yorkshire and the Humber. Many of the very worst performing local areas are in the East Midlands and the East of England. Figure 3.3 shows how the English regions are represented within the coldspot quintile of the index. London is notably absent, as even its worst performing area is in the top third nationally.

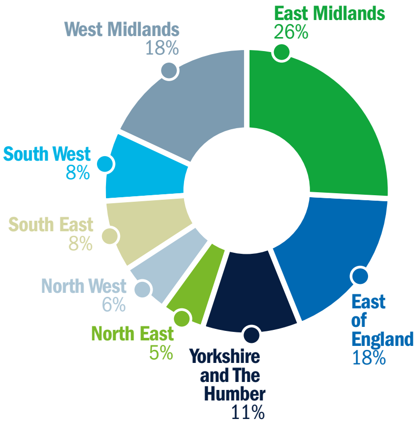
While the Social Mobility Index reflects the overall economic prosperity of London and the South East, it also adds a layer of detail in the wide variability of potential social mobility on a much more local level.

Figure 3.2: Regional distribution of social mobility hotspots



Source: Social Mobility & Child Poverty Commission[3.32]

Figure 3.3: Regional distribution of social mobility coldspots



Source: Social Mobility & Child Poverty Commission[3.32]

3.3 The UK workforce

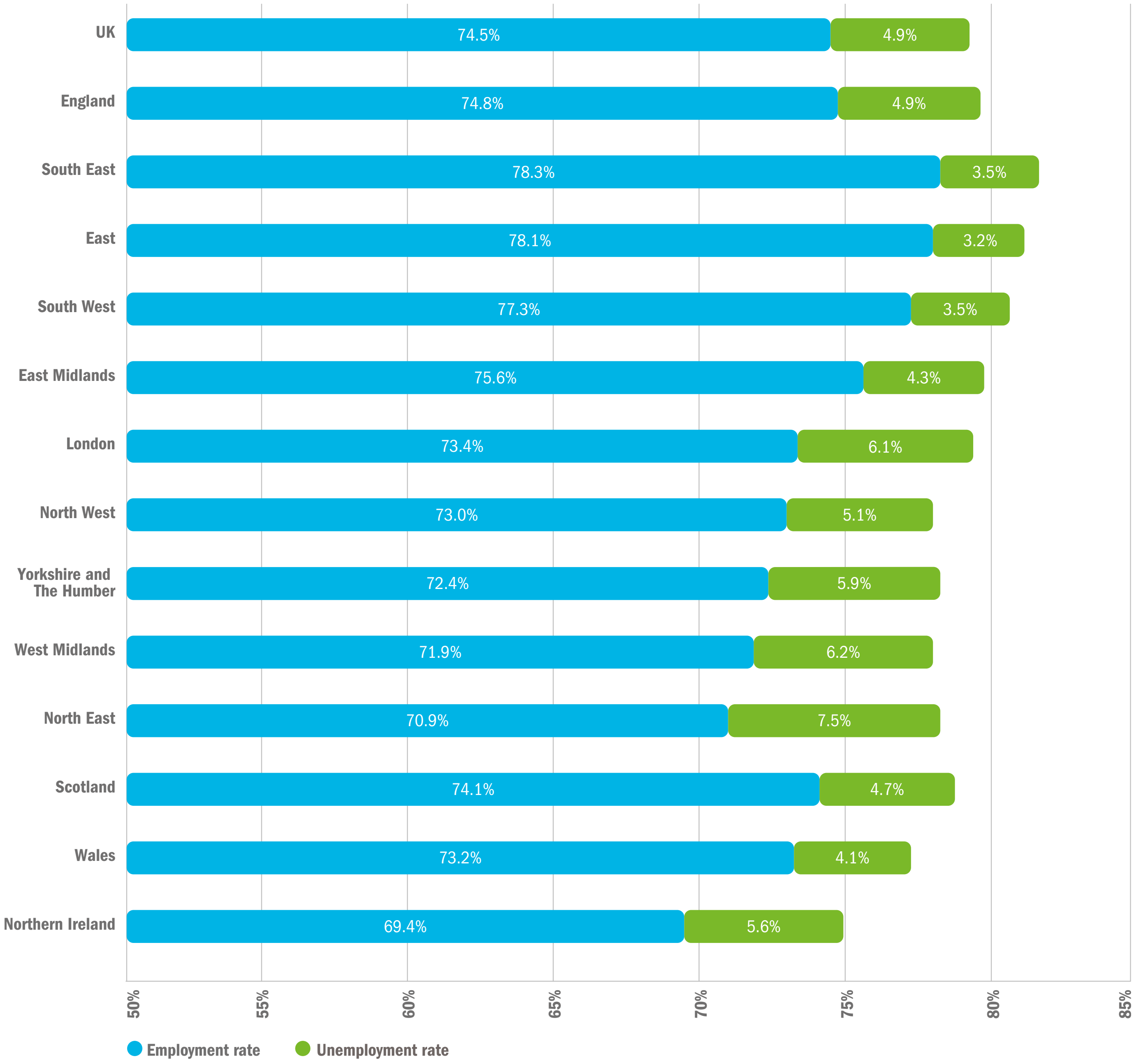
3.3.1 Extent of the UK workforce

According to the most recent Labour Force Survey, in May to July 2016 there were just under 31.8 million people in work in the UK: about 175,000 more than the previous quarter and 560,000 more than a year earlier.[3.33] Of these, 30.6 million were aged 16-64 years, which is the key group analysed in the working population. In total, 23.2 million people were working full-time (435,000 more than a year earlier) and 8.5 million were working part-time (125,000 more than a year earlier).

The employment rate (the proportion of people aged 16-64 who were in work) was 74.5% for the UK, the joint highest rate since comparable records began in 1971. There were 1.63 million unemployed, which was 40,000 fewer than the previous quarter, and 190,000 fewer than in the same period in 2015. At 4.9%, this was the lowest unemployment rate since spring 2008.

Figure 3.4 illustrates the employment rate across the UK's nations and regions. It shows that employment among 16- to 64-year-olds was highest in the South East (78.3%) and the East of England (78.1%), which also had the lowest unemployment rate, at 3.5%. Northern Ireland (at just under 70%), the North East and the West Midlands had employment rates at the bottom end of this range. The unemployment rates are also included in Figure 3.4 (the 'missing' element is the proportion of adults in this age range who were not economically active).

Figure 3.4: Employment and unemployment rate amongst those aged 16-64 years, by region/nation (May – July 2016)[3.34]



Source: ONS

3.33 ONS: *UK labour market statistical bulletin*, September 2016. http://www.ons.gov.uk/employmentandlabourmarket/peopleinwork/employmentandemployeetypes/bulletins/uklabourmarket/september2016 3.34 ONS: *Regional labour market statistics in the UK*, September 2016. https://www.ons.gov.uk/employmentandlabourmarket/peopleinwork/employmentandemployeetypes/bulletins/regionallabourmarket/sep2016

A somewhat contentious aspect of the workforce currently is its nationality profile. Of the 31.8 million in employment in 2016, around 3.45 million were non-UK nationals. During the previous year, the number of non-UK nationals working increased by 245,000 (7.5%), while the number of employed UK nationals rose by only 1.5%. The increase in non-UK nationals is largely attributable to people coming from the European Union (up 238,000 to 2.23 million in the year to July 2016). The number of non-UK nationals from outside the EU working in the UK was little changed at 1.21 million.

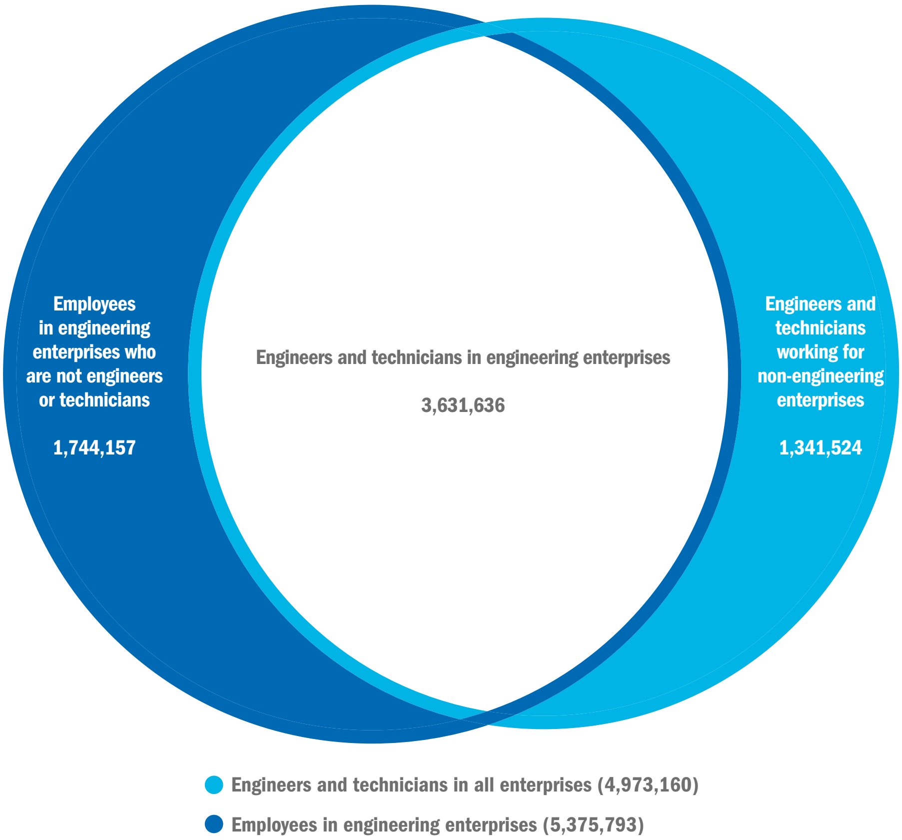
3.3.2 Size of the engineering workforce

As shown in Chapter 2, the UK engineering sector is vast in terms of both its contribution of 26% to the UK's Gross Domestic Product (GDP) and in employing around 5.7 million people, which is about 19% of the UK's total workforce.

Last year EngineeringUK used Office for National Statistics' Annual Population Survey (APS) 2014 data to estimate the number of engineers and technicians working within the engineering sector, the number of engineers and technicians working in other sectors, and the number of employees other than engineers and technicians working within the engineering sector. This gave a breakdown of 5,375,793 employees in engineering enterprises, two thirds of whom (3,631,636) worked as an engineer or technician.[3.35] That left 1,744,157 other employees in engineering enterprises (such as administrative, business and financial workers). There were 4,973,160 engineers and technicians in the total workforce, of whom a quarter (1,341,524) were working in the wider economy. These proportions are most easily portrayed graphically (Figure 3.5).

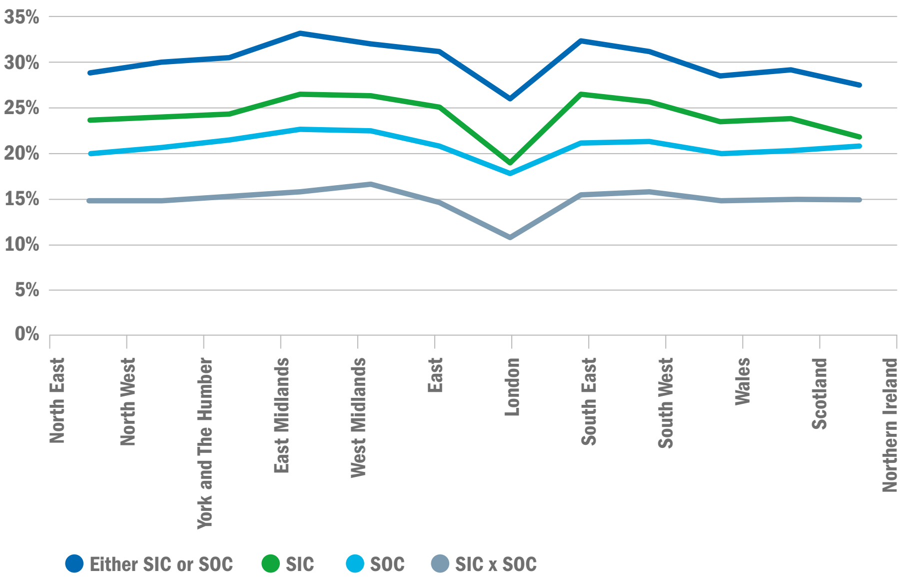
As we discussed in Chapter 2, the number of people in the engineering workforce varies markedly by region when measured by size of enterprise, although the variation is smaller when you look at the engineering workforce as a proportion of the total workforce. Using data from the Annual Population Survey suggests that in 2015, the regions with the largest numbers working in the engineering sector were the South East and London, at over 1.2 million each. This was followed by the North West, at just under 1 million. The smallest regions were Wales (380,000), the North East (330,000) and Northern Ireland (220,000). These numbers were based on those working in either a SIC-based definition of engineering or a SOC-based footprint of engineering occupations.

Figure 3.5: Number of employees in engineering enterprises, engineers and technicians in the total workforce and engineers and technicians in engineering enterprises (2014)



Source: ONS[3.36]

Figure 3.6: Proportion of workforce employed in engineering, by region/nation (2015) – UK



Source: ONS - (APS)

3.35 Defined by EngineeringUK using the ONS' system of Standard Industrial Classification (SIC) and Standard Occupational Classification (SOC) codes **3.36** In-house analysis conducted using EngineeringUK's SIC/SOC engineering footprint of ONS: *Annual Population Survey*: January-December 2014, March 2015, Workbook: Four/Five digit industry (SIC) cross-referenced with four digit occupation (SOC) (Jan-Dec 2014). http://www.ons.gov.uk/ons/about-ons/business-transparency/freedom-of-information/what-can-i-request/published-ad-hoc-data/labour/march-2015/four-five-digit-industry--sic-.xls

Back to Contents

When looking at engineering as a proportion of total employment in 2015 (Figure 3.6), we find it most dominant in the East Midlands, the South East and the West Midlands, the latter accounting for around one in three workers. The smallest proportions were in Northern Ireland (27%) and London (26%).

This pattern was relatively consistent whether we used the broad definition of the engineering workforce above, or solely defined it by either the SIC or SOC footprint, or the 'core' of the workforce, that is, those working in an engineering occupation within an engineering organisation (SICxSOC). The position of London as a region with a high number of engineering workers but who constitute a much lower proportion of the total workforce (due to London's very large service-based economy) is particularly prominent in this latter representation.

Table 3.13 is not based specifically on engineering – rather, it takes a wider view, looking at the proportion of residents in each Local Enterprise Partnership (LEP) in England employed in science, research, engineering and technology professions and associated professions. It also dates to 2014. Nevertheless, it is useful in giving a more granular view of the English employment landscape, revealing the proportions of people working in STEM-related professions. Across England, 7.2% worked in STEM and related professions. All of the LEPs where this was 10% or higher were in the south of England.

Table 3.13: Residents employed in science, research, engineering and technology professions and associated professions by Local Enterprise Partnership (LEP) (July 2013 – June 2014) – England

LEP area	Region	Percentage of all in employment who are in 'science, research, engineering and technology' professions and associated professions
Oxfordshire	South East	12.9%
Thames Valley Berkshire	South East	12.6%
Greater Cambridge and Greater Peterborough	East of England (part East Midlands)	10.9%
West of England	South West	10.2%
Enterprise M3	South East	10.0%
Cheshire and Warrington	North West	9.3%
Swindon and Wiltshire	South West	9.1%
Buckinghamshire Thames Valley	South East	9.0%
Hertfordshire	East of England	8.6%
Solent	South East	8.2%
Coventry and Warwickshire	West Midlands	7.7%
Worcestershire	West Midlands	7.7%
Cumbria	North West	7.6%
Leicester and Leicestershire	East Midlands	7.6%
London	London	7.6%
Gloucestershire	South West	7.5%
South East Midlands	East Midlands (part South East and East of England)	7.3%
Coast to Capital	South East (part London)	7.1%
York, North Yorkshire and East Riding	Yorkshire and The Humber	6.8%
Derby, Derbyshire, Nottingham and Nottinghamshire	East Midlands	6.6%
The Marches	West Midlands	6.6%
Dorset	South West	6.6%
Tees Valley	North East	6.4%
Greater Manchester	North West	6.3%
Greater Birmingham and Solihull	West Midlands	6.3%
Lancashire	North West	6.2%
South East	South East (part East of England)	6.1%
Leeds City Region	Yorkshire and The Humber	6.0%
New Anglia	East of England	5.9%
North Eastern	North East	5.9%
Stoke-on-Trent and Staffordshire	West Midlands	5.9%
Sheffield City Region	Yorkshire and The Humber (part East Midlands)	5.8%
Liverpool City Region	North West	5.8%
Heart of the South West	South West	5.6%
Northamptonshire	East Midlands	5.6%
Humber	Yorkshire and The Humber	5.3%
Cornwall and Isles of Scilly	South West	5.2%
Greater Lincolnshire	East Midlands (part Yorkshire and The Humber)	5.1%
Black Country	West Midlands	4.4%
England	-	7.2%

Source: ONS through BIS[3.37]

3.37 BIS: *Mapping local comparative advantages in innovation: framework and indicators*, July 2015. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/546999/bis-15-344-mapping-local-comparative-advantages-in-innovation-framework-and-indicators.pdf

3.3.3 Demographics of the engineering workforce by the Institute of Employment Studies

3.3.3.1 Age profile

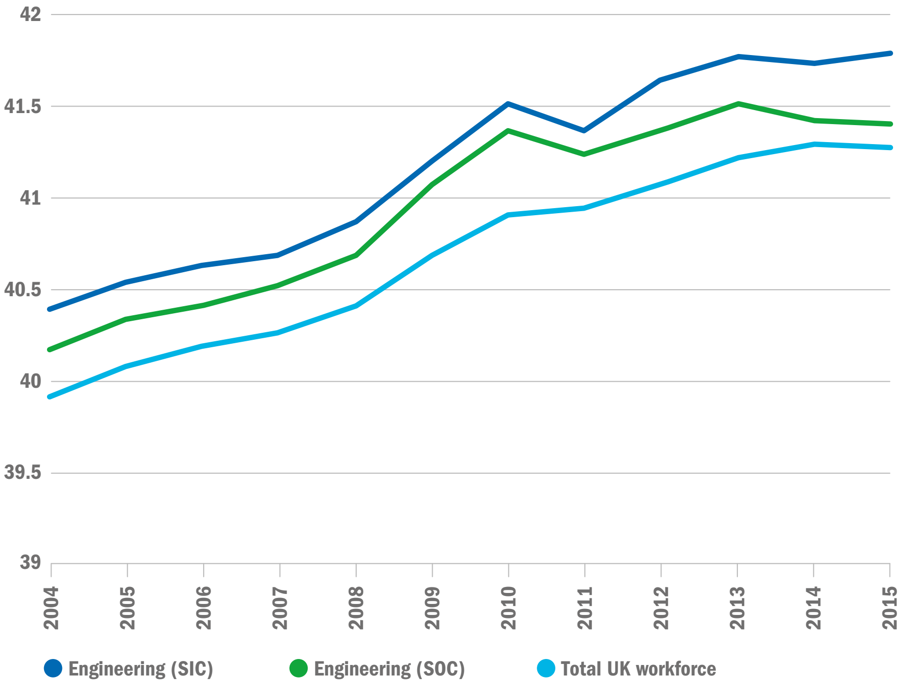
Data from the UK Annual Population Survey has been used by the Institute of Employment Studies to analyse the demographics of the current engineering workforce, based on EngineeringUK's sector (SIC-based) and occupational (SOC-based) footprints. This reveals that in 2015, the average age of the engineering workforce was slightly – but only very slightly – older than the UK workforce as a whole. In 2015, the mean age of workers within the engineering SIC footprint was 41.75 years, compared with the average age of all UK workers of 41.25 years. (A comparable analysis using the SOC footprint gave a mean of 41.4 years).

Figure 3.7 shows the age profile of these alternative engineering footprints in comparison to the workforce as a whole in 2015. There were fewer young workers (aged under 25) in engineering than overall, and also very slightly fewer older workers (aged 55 and over). The age profile is broadly similar across the SIC and SOC footprints.

On average, the workforce has been getting older since 2004, both overall and in the engineering sector and its occupations (Figure 3.8). Between 2004 and 2015, the average age of workers in the engineering sector footprint increased from 40.38 years to 41.75 years, which was approximately half a year greater than the average age of all workers during this period. The average age of those working in engineering occupations fluctuated between these two series of averages during this time. Data from the Labour Force Survey has also been used, in a parallel analysis, and shows a very similar trend over this period.

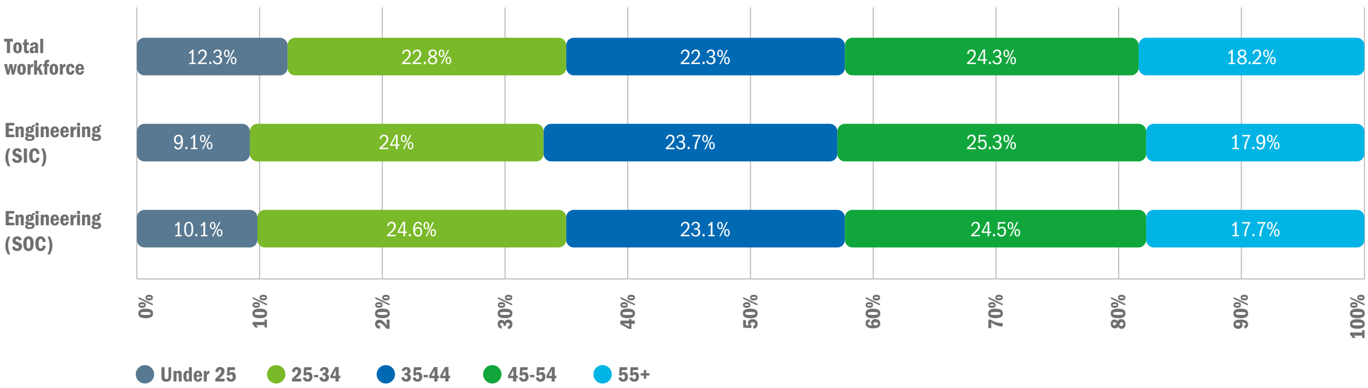
However, at the core of the engineering workforce are those who work in both an engineering sector organisation and an engineering occupation, referred to as 'SIC x SOC' in these charts. Figure 3.9 shows the trend in the age profile of this core group of the workforce from 2004 onwards. This shows a significant increase in the proportion of workers aged 45 and over, who made up 35% of the workforce in 2004 but had risen to over 41% by 2015. The proportion of workers aged 25-34 remained broadly stable, at around a quarter of

Figure 3.8: Mean age in years of engineering (SIC, SOC) and total UK workforces, over time (2004-2015)



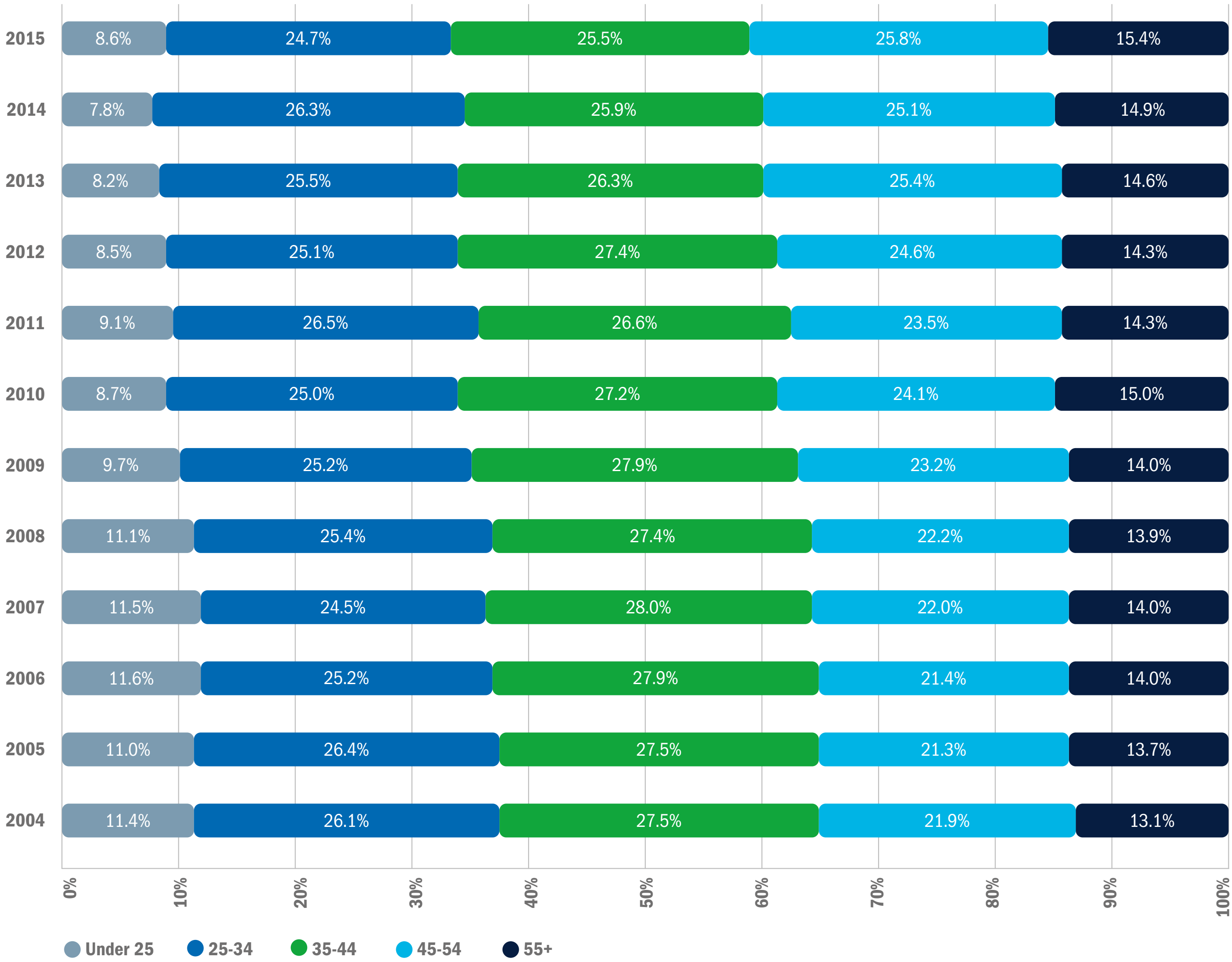
Source: ONS - (APS)

Figure 3.7: Age profile of the total engineering workforces (2015) – UK



Source: ONS - (APS)

Figure 3.9: Age profile of core engineering workforce (SIC x SOC), (2004-2015)



Source: ONS - (APS)

all workers, while the proportions of ages under 25 and 35-44 have both fallen. The proportional decrease in those aged under 25 has been particularly significant.

An analysis of both age and geographical nation/region together indicates that, based on the SIC footprint, engineering workers are on average youngest in London and Northern Ireland, with a mean age of 40. In all other regions, the average age of comparable workers is over 41 years, and in the East and West Midlands, the East of England, the South East and the South West, it is over 42. Use of the SOC footprint gives broadly similar results but with generally slightly younger mean ages. The proportion of engineering workers aged 55 and over is important, given its potential to signpost those soon to retire from the sector. Looking at the over-55s geographically gives broadly similar results to the distribution by mean age. London and Northern Ireland have the lowest proportions of engineering workers aged 55 and over, while the Midlands, the East of England, the South East and the South West have the highest proportions of workers who are close to retirement.

3.3.3.2 Gender profile

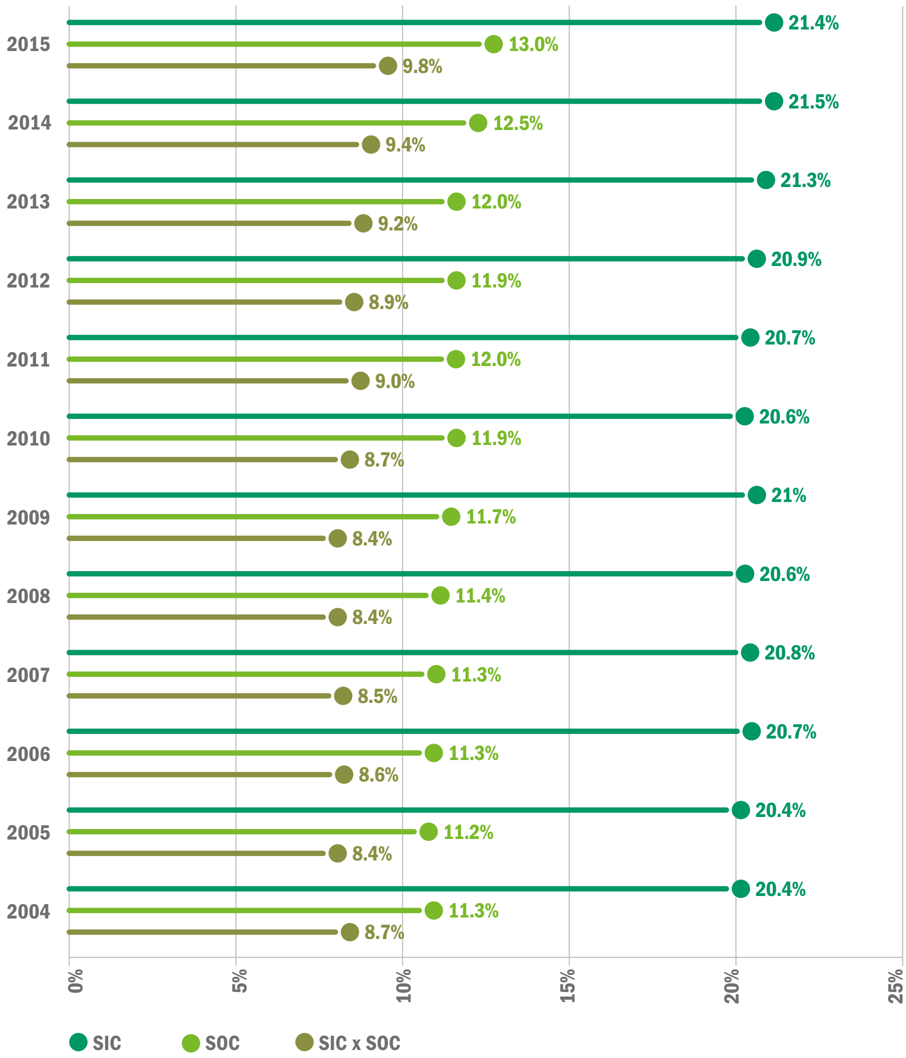
The UK engineering workforce is well known as being male-dominated. This is demonstrated in the sector-based footprint, and even more so in the SOC-based footprint, as shown in Figure 3.10. In 2015, women made up just over one fifth (21%) of the engineering workforce, according to the SIC footprint, but only accounted for one in eight workers (13%) of those in engineering occupations. They comprised an even smaller proportion (just under 10%) of the 'core' (SIC x SOC) engineering workforce, through this analysis at least. The general trend since 2004 has been a slight increase in the proportion of women, which has been more significant amongst engineering occupations than in engineering sectors or the core engineering workforce.

In comparison, women comprised around 46% of the workforce across all sectors and occupations, a proportion that has risen only fractionally (from 45.8% to 46.6%) during this period.

Women in engineering are on average younger than men. Figure 3.11 shows the trends in average age by gender for the different engineering footprints. It shows that since 2004, women in engineering have been consistently around one year younger in mean age than men. All groupings show an increase in the mean age over the period, although the trend is more steady for men and has been tailing off in recent years. The patterns for women are less steady. There was some volatility around 2008, especially in engineering occupations, and a stronger downward turn than for men around 2010-2011 – both periods of recession in the UK.

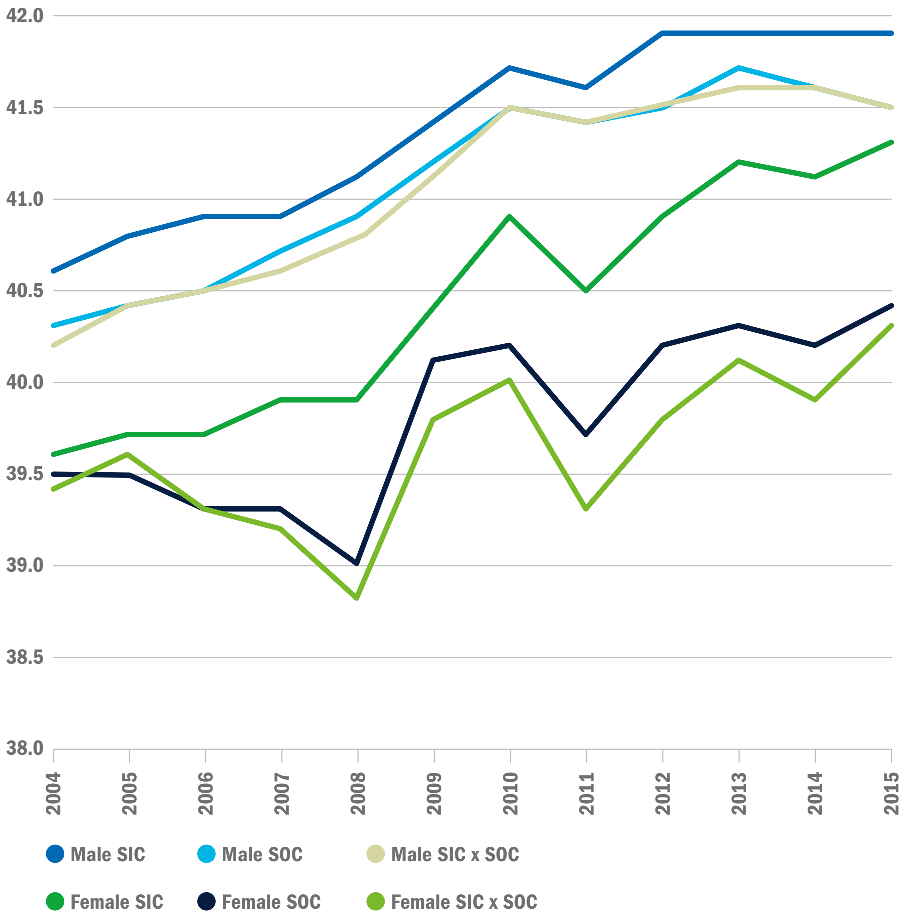
Figure 3.12 shows the age profile by gender for the different engineering footprints in 2015. Across all these footprints, there were fewer women than men among the under-25s (the youngest group), and among the over-55s (the latter driven by the difference in pension ages). Equalising the pension age for men and women will reduce these differences at the upper end of the age profile in future years. However, the lower representation of women in the lowest age group suggests that the male-orientation of the engineering workforce is not going to disappear soon without deliberate interventions.

Figure 3.10: Proportion of females in the engineering workforce footprint, over time (2004-2015)



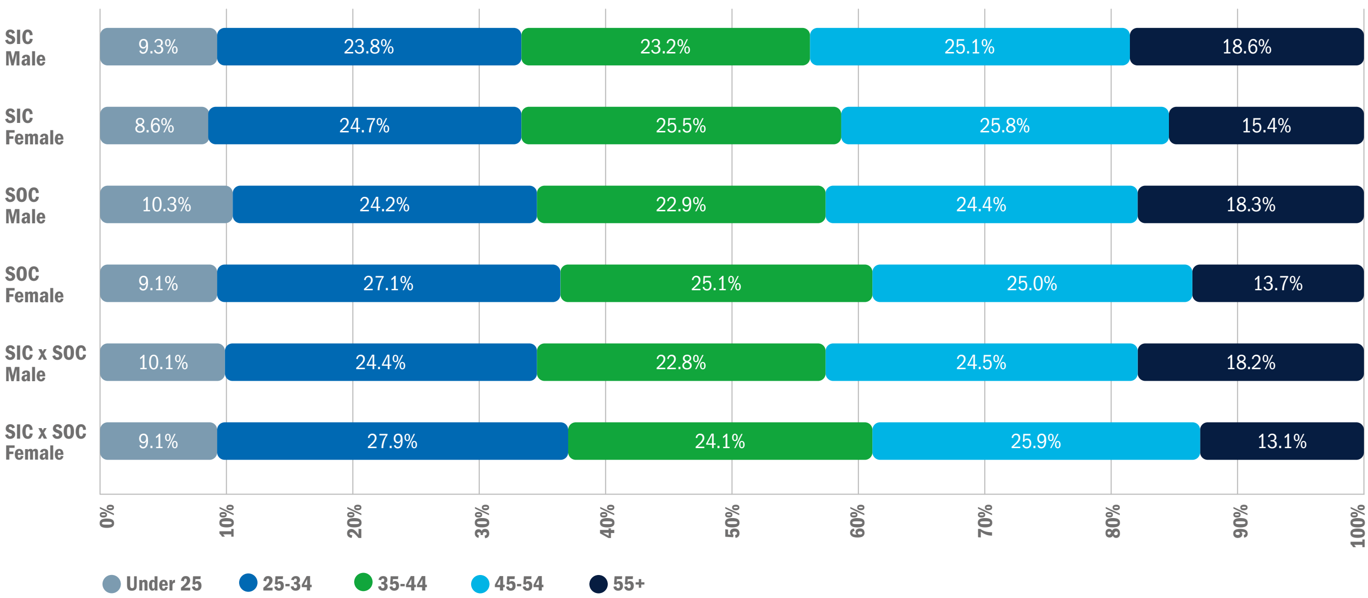
Source: ONS - (APS)

Figure 3.11: Mean age (years) of engineering workforce, by gender over time (2004-2015)



Source: ONS - (APS)

Figure 3.12: Age profile of different engineering workforce footprints, by gender (2015)



Source: ONS - (APS)

Back to Contents

Part 1 – Engineering in Context
4 Understanding and influencing target audiences

Key points

Improving perceptions

Young people's perceptions of engineering have grown more positive in the last five years. The proportion of 11- to 16-year-olds who would consider a career in engineering has risen to 54% in 2016. This upward trend is somewhat more pronounced among 11- to 14-year-olds than 15- to 16-year olds, but is rising fastest amongst those of sixth form age (17-19).

The picture among those who influence young people educators is also positive. The vast majority of teachers would recommend a career in engineering to their pupils, and three quarters of parents view engineering positively as a career.

While parents are just as likely to recommend a vocational route into engineering as an academic one, pupils and teachers are more likely to anticipate and favour academic routes into engineering.

A further concern is that teachers have greater confidence in their pupils' knowledge of engineering than the pupils do themselves: 45% of STEM educators believe their pupils know what people in engineering do, but fewer than one third of young people. Engineering is the area of work relating to STEM subjects that they know the least about.

There is evidence that more positive attitudes towards STEM careers are having an impact, but still too few young people are deciding to continue to study the subjects that keep the doors to engineering careers open. This limits the number who ultimately will be able to enter highly-skilled engineering careers.

Careers education and guidance

It is increasingly acknowledged that effective careers education and interventions during school are vital to developing more informed careers thinking, and that agreement is needed on some of the aspects of delivering it well. Good careers support engages a wider variety of young people (including more from disadvantaged groups) in thinking more about their subject and career choices. However, careers advice and guidance in state schools is patchy at best and highly under-resourced. Indications are that the majority of pupils currently do not have access to substantive careers guidance.

There is evidence that employer engagement has an important role in helping young people make good decisions, and that participation (particularly in Key Stage 3) can have a distinct impact on earnings in adult life.

There is a necessary and growing focus on the quality and impact of interventions for young people, especially in schools. There are myriad opportunities on offer that will allow schools to offer activities relating to STEM careers, but they struggle to differentiate between them. STEM-related learning and communication activities need to be better co-ordinated and evaluated, so that their use is optimised and they achieve greater reach and long-term impact on young people.

This chapter outlines the baseline perceptions of young people and their influencers. It then reviews the latest thinking on how to improve take up of STEM subjects and engineering career routes – focusing on employer engagement, careers education and guidance, diversity and inclusion.

4.1 Baseline perceptions

The Engineering Brand Monitor (EBM)[4.1] is EngineeringUK's annual survey of engineering and STEM perceptions among nationally-representative samples of young people, adults and STEM educators. It is used not only as a benchmark of perceptions for EngineeringUK's engagement activities, but also by the wider engineering and STEM community. On this basis, underlying perceptions about engineering and science have improved notably over the last five years, but much work remains to be done.

The period 2013-2016 has seen an increase in the proportion of 11- to 16-year-olds who would consider a career in engineering, from 48% in 2013 to 54% in 2016. However, the upward trend is more pronounced, and steadier, among 11- to 14 year-olds than 15- to 16-year-olds.[4.2] As shown in Figure 4.1, older pupils are less likely to consider a career in engineering (54% of 11-14s, but 46% of 14-16s), suggesting that a key challenge is sustaining pupils' interest as they progress. To retain interest and motivation over the longer term, opportunity must also be maintained. Routes into engineering careers become progressively cut off for many when students make their subject choices at 14 and 16.

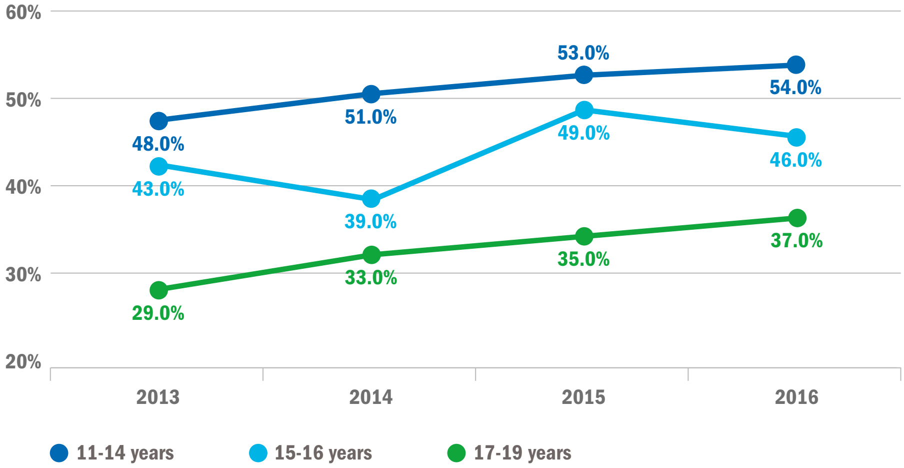
4.1 See EngineeringUK: http://www.engineeringuk.com/Research. Previous editions were called *The Engineers and Engineering Brand Monitor* (EEBM). **4.2** Strictly some of these pupils will have been aged 14 years, as this grouping constitutes those in school years 10 and 11 in England or equivalent.

Post-16, the proportion of those who would consider a career in engineering has grown more rapidly than among younger pupils: 37% of 17- to 19-year-olds would consider a career in engineering, compared with 29% in 2013. Over four years, this represents a 28% increase for this age group, compared with a 13% improvement among respondents aged 11 to 16.

There has been less year-on-year change in the perceived desirability of engineering careers (Figure 4.2). The four-year trend has been much more static among pupils/students than their teachers, who have shown a dramatic increase in their likelihood of seeing a career in engineering as desirable (from 57% in 2014 to 79% in 2015). In 2016, educators were almost twice as likely as pupils to believe that a career in engineering is desirable.

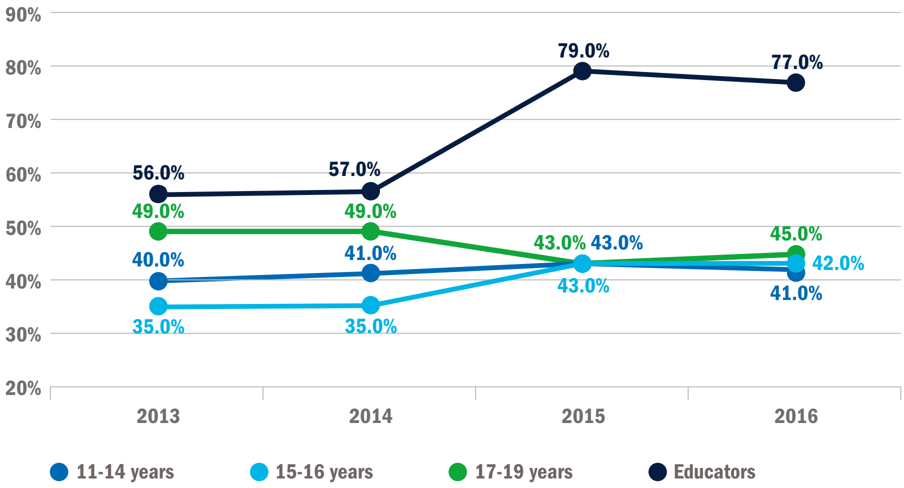
While a substantial minority of pupils of all ages saw engineering as a desirable career, it was less likely to be seen in a positive light than other STEM career areas. And although 33% of 11- to 14-year-olds agreed that engineering 'fits well with who I am', this fell to 29% among 15- to 16-year-olds and 24% among 17- to 19-year-olds.

Figure 4.1: Young people aged 11-14, 15-16 and 17-19 who would consider a career in engineering (2013-2016) – UK



Source: EBM 2016; EEBM 2015

Figure 4.2: Young people aged 11-14, 15-16 and 17-19, and educators, who believe a career in engineering is desirable for them/their pupils (2013-2016) – UK



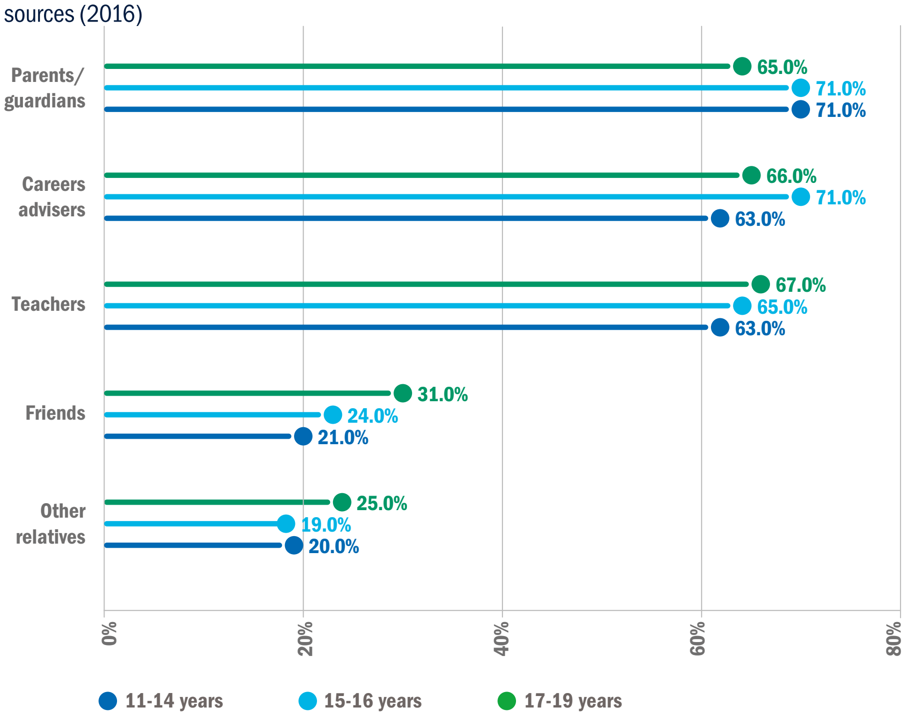
Source: EBM 2016; EEBM 2012-2015

Young people of all ages reported that the people they would most go to for careers advice were parents, careers advisers and teachers (Figure 4.3). Parents, however, felt they knew more about technology careers than about those in engineering (and science). While the vast majority of teachers (96%) would recommend a career in engineering to their pupils, they are considerably less able to pass on relevant knowledge. Although three in five (61%) STEM teachers of 14- to 19-year-olds have been asked for careers advice about a job in engineering, just one-third of STEM teachers (35%) felt confident about giving advice on engineering careers.

Young people in all age groups reported that they would be more likely to *act on* the advice of parents and careers advisers than teachers (Figure 4.4). Among 11- to 16-year-olds, a third are likely to the swayed by the advice of parents and careers advisers, but only one in eight would be swayed by careers advice from teacher. Guidance from careers advisers was more likely to sway 17- to 19-year-olds than advice from parents (34% compared with 25%), with teachers a closer third at 18%. School or college, however, is an important source of careers ideas and influences, as shown by the study[4.3] for City & Guilds discussed later in the chapter.

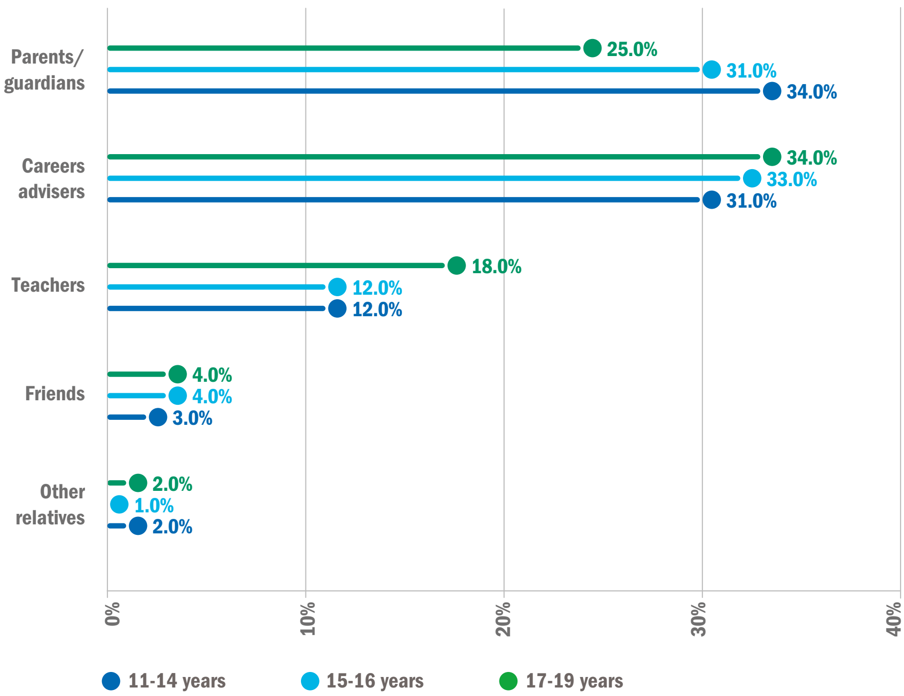
Most parents viewed engineering as a career positively, although not to the same extent as teachers: 76% of parents responding to the EBM would recommend engineering careers to their children. However, parents were just as likely to recommend a vocational route as an academic one, whereas pupils and teachers were more likely to favour academic routes into engineering.

Figure 4.3: Proportion of pupils who would consider seeking careers advice from different sources (2016)



Source: EBM 2016

Figure 4.4: Proportion of pupils who would act upon careers advice from different sources (2016)



Source: EBM 2016

4.3 City & Guilds: *Great expectations: teenagers' aspirations versus the reality of the job market*, 2015. http://www.cityandguilds.com/~/media/Documents/Courses-and-Quals/Apprenticeships/EMSI%20 reports/cggreatexpectationsonline%20pdf.ashx

A further concern is that teachers have greater confidence in their pupils' knowledge of engineering than pupils do themselves. Of the STEM educators surveyed in 2016, 45% believe their pupils know what people in engineering do, but knowledge among students remains at around one-third of young people for all age groups, as shown in Figure 4.5. Across the 11-19 age range, engineering is the area of work relating to STEM that pupils know the least about.

However, through interventions such as The Big Bang Fair and Tomorrow's Engineers, these perceptions can be improved. Comparing post-event surveys of 11- to 14-year-olds who had attended The Big Bang Fair[4.4] with their peers in the general population:[4.5]

- 75% of attendees had positive perceptions of engineering compared with 47% in the general population;
- 58% said they know what people who work in engineering do, compared with 30% (with a bigger difference in the case of girls: 56% compared with 20%);
- 61% agreed that a career in engineering is desirable, compared with 43% (55% of girls agreed, compared with 30% of boys).

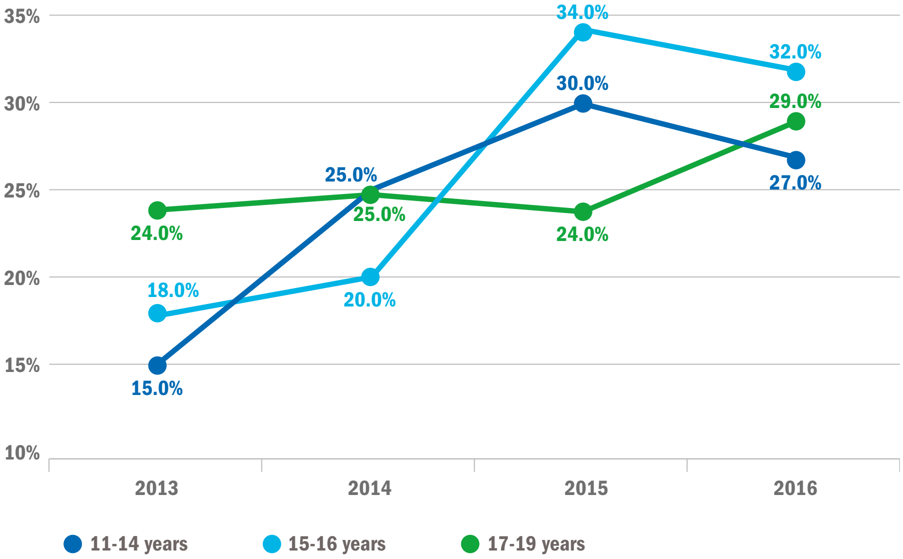
The Big Bang Fair is also successful at demonstrating that engineering is a suitable career for both boys and girls: 84% of 11- to 14-year-olds attendees were convinced of this, compared with 71% in the general 11– to 14-year-old population. Among girls, the contrast was particularly marked: 87% surveyed at the fair believed this statement, compared with 67% of the population accessed through the EBM.

Evaluation of the Big Bang Fair programmes and Tomorrow's Engineers also shows the positive impact on career thinking of being able to speak to engineers.[4.6] This confirms the value and influence of direct contact with people working in relevant roles.

This is borne out by a City & Guilds study into career aspirations which found young people's thinking to be ill-informed, and poorly matched to the actual opportunities of the projected labour market of 2020.[4.7] When asked what occupations they would consider, young people selected from:

a relatively narrow pool of jobs that represented just 34% of the roles that will be available. Overall, almost two-thirds of the jobs were not selected by anyone.... The jobs most frequently chosen are ones that young people would commonly be exposed to (secondary school teacher, police officer, doctor) or ones that they may have seen in media representations.

Figure 4.5: Percentage of pupils (aged 11-19) who say they know what people working in engineering do (2013-2016)



Source: EBM 2016; EEBM 2013-2015

4.4 IFF Research for Big Bang Education CIC: *EngineeringUK evaluation – Big Bang Fair 2016 report*, July 2016. **4.5** IFF Research: *Engineers and Engineering Brand Monitor 2015*, 2015. http://www.engineeringuk.com/_resources/documents/Sep-2015-Engineers-and-Engineering-Brand-Monitor-2015-1.pdf **4.6** IFF Research: *EngineeringUK evaluation – Big Bang Fair 2016 report*, 2016. **4.7** City & Guilds: *Great expectations: teenagers' aspirations versus the reality of the job market*, 2015. http://www.cityandguilds.com/~/media/Documents/Courses-and-Quals/Apprenticeships/EMSI%20reports/cggreatexpectationsonline%20pdf.ashx

As shown in Table 4.1, school or college had the greatest influence on career ideas. City & Guilds is concerned that the relatively minor influence of employer contact means young people "may not have an accurate understanding of what the role of their choice is like and crucially …only consider roles that they see in their immediate sphere of influence."

The study also showed that although young people had high salary expectations, their understanding of the kinds of jobs that would help achieve these was poor. The EBM 2016 backs up this finding. 'Pay' is one of the top three factors (along with 'something I'm interested in' and 'enjoyment') that young people consider most important when choosing careers. However, four in ten young people were not aware that engineering is a well-paid profession: 42% of 11-14s and 37% of 15-16s rated engineering averagely paid or not well paid. Only 20% of 17- to 19-year-olds correctly estimated graduate engineers' starting salaries as being in the £25,000-£29,999 bracket while nearly 60% underestimated them (Table 4.2).

Table 4.2: Graduate engineer starting salaries: perceptions of 17- to 19-year-olds (2015-2016) – UK

Graduate engineer starting salary estimate	2015	2016
Under £10,000	7%	3%
£10,000 – £14,999	14%	11%
£15,000 – £19,999	24%	19%
£20,000 – £24,999	31%	25%
£25,000 – £29,999 (actual)	**10%**	**20%**
£30,000 – £39,999	5%	6%
£40,000 and over	1%	3%

Source: Engineering Brand Monitor 2016;
Engineers and Engineering Brand Monitor 2015

Young people's influencers also significantly underestimated pay when asked for their views of the average salary of a professional engineer. The mean average response given by parents was £46,100, by teachers £45,954, and by non-parents £42,589. However, recent figures relating to the average salary of Chartered Engineers are a mean of £68,539 and a median of £60,000.[4.8]

These findings on perceptions about earnings show the importance of getting across accurate careers information. Young people's perception of engineers' pay has at least moved in the right direction. The mean average response in 2016 was £22,535, whereas in 2015 it was only £19,744. However, estimates of professional engineers' salaries among adults remained very similar across the 2015 and 2016 surveys.

Table 4.1: How young people heard about the job of their choice

We learned about it in a class in school/college	30%
I saw it in the media	28%
I already know someone who works in that industry	26%
I went on a work experience placement in this industry	21%
My parents suggested it	21%
A teacher/lecturer suggested it	16%
A careers adviser recommended it	14%
An employer came into my school to talk about this industry	9%
We visited a local business/organisation with my school/college	6%

Source: City & Guilds

4.2 Effective intervention

Positive trends in perceptions have done little to reduce the national shortfall of STEM-qualified students interested in engineering careers. A recent Royal Academy of Engineering (RAEng) report discusses "the complex interplay of issues affecting involvement and interest in engineering" post-16. It highlighted the perceptions of young people and their influencers; professional development of teachers for applied learning; school performance measurement drivers; careers education, information, guidance and employer engagement; and issues with facilities and capacity across the educational landscape.[4.9] It concludes that too many pupils disengage with STEM through failure to see its relevance to their current life and future directions, and underlined "the need for improved careers guidance and employer engagement and better articulation of the many pathways open to young people after school."

The RAEng is in no doubt that employer engagement, effectively *deployed*, is "a powerful tool for influencing young people's career aspirations. Student engagement with employers will reduce their likelihood of being NEET (not in education, employment or training)." The Education and Employers Taskforce has found that students who had four or more interactions with employers while in education were five times less likely to be not in employment, education or training (NEET) than those who did not recall such activities.

Another key issue, the RAEng suggests, is "the need for more teachers to engage in professional development that improves their understanding of the application of science and mathematics to real-life contexts." A report by the Institution of Mechanical Engineers (IMechE) argues that engineering's lack of visibility within the UK education system is exacerbated by bias towards the natural world rather than the 'made world' in school science teaching. It urges a new focus in schools on the presence of engineering and the 'made world' at all stages from primary level upwards.[4.10] Discounting major curriculum overhaul as unrealistic, the report recommends an approach that works within existing educational frameworks. It advises that:

…enhancing teachers' confidence and ability to embed frequent references to engineering and engineering careers within their teaching would not only support their pupils in making choices but also emphasise that, although science and mathematics are the prevalent STEM subjects in schools, in the external world, it is engineering and technology that predominate.

Some other systemic issues that impact on students' lack of engagement with engineering and STEM more broadly – such as the supply of STEM-qualified teachers and developments in academic and vocational routes – are discussed in Chapter 5. Here we focus on the issues in career- and work-related learning within the schools system. The RAEng *UK STEM Education Landscape* study found that more than 600 UK organisations run initiatives that seek to engage schools with STEM. The majority of these organisations are specialist education enrichment providers, but others include learned societies and professional bodies, science discovery centres, field study centres, subject associations and teacher support organisations. Many undertake a range of activities, from direct interactions with school students and teacher continued professional development programmes to providing policy advice and guidance to government and other agencies. However, the list was not thought to be exhaustive and many more small providers are likely to exist, providing various forms of support to young people. The mapping also did not include employers or universities, which provide significant support to the education system.

For employer engagement to have real impact, it argues, activity must be more effectively co-ordinated and more extensive evaluation must identify which interventions have long-term positive impact on young people.

4.8 Engineering Council. *The Engineering Council 2013 Survey of Professionally Registered Engineers and Technicians, 2013.* https://www.engc.org.uk/engcdocuments/internet/Website/2013%20Survey%20of%20Registered%20Engineers%20and%20Technicians.pdf **4.9** Royal Academy of Engineering: *The UK STEM education landscape*, 2016. www.raeng.org.uk/stemlandscape **4.10** Institution of Mechanical Engineers: *Big ideas: the future of engineering in schools*, April 2016. https://www.imeche.org/policy-and-press/reports/detail/big-ideas-report-the-future-of-engineering-in-schools

4.2.1 The evidence base

Research that gives insights into the experiences of different groups of young people helps the STEM community to develop more nuanced intervention strategies. Analysis of findings from large-scale studies suggests that higher priority should be given to misconceptions about where STEM study can lead. Interventions that focus too narrowly on improving enjoyment of STEM, it is suggested, often lack long-term impact on pupils' subject choices.

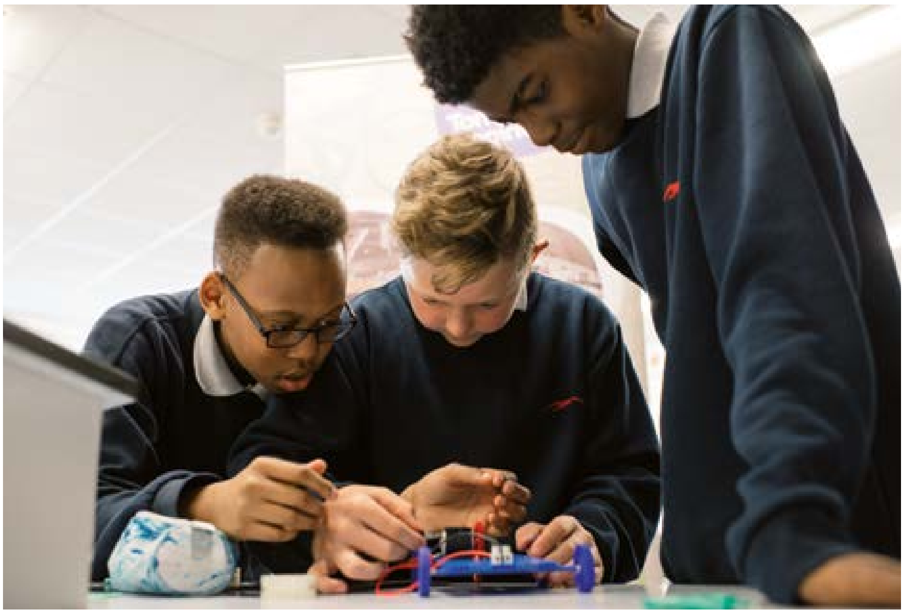
The *ASPIRES* project,[4.11] the major ten-year study investigating science and careers aspirations at age 10-19, has found that "most young people do enjoy school science and express positive views of scientists. However, most young people struggle[d] to name any science careers beyond 'scientist' and 'science teacher.'" In addition, it concludes that the persistent image of science (especially physics) as a 'masculine' subject, which is only for the 'brainy', impacts particularly negatively on girls, working-class and some minority ethnic students.[4.12] Interventions therefore need to help these groups build confidence in persevering with STEM subjects.

Recent research[4.13] developed in partnership with the Your Life campaign[4.14] reviewed the ASPIRES findings on STEM participation, together with those of the earlier UPMAP[4.15] project. It found a number of drivers impacting both boys' and girls' STEM participation, with girls additionally hampered by lower aspirations towards science-related careers. In order of importance for participation, these were:

1. Career relevance – many students do not associate studying science subjects with getting a good job: this perception particularly affects decisions to study physics;
2. Ability to do well in subject – impacts both maths and physics;
3. Adult (teacher and parent) encouragement – has more bearing on studying maths;
4. Interest and enjoyment -similar impact for maths and physics;
5. Low appeal of STEM careers (girls only) – higher impact on aspirations towards engineering than science careers.

To encourage more young people from more diverse backgrounds into science post-16 and STEM careers, *ASPIRES* recommends that influencers:

- Focus on the message that science is useful for any career;



- Challenge the 'brainy' image of science, and especially physics;
- Build young people's 'science capital' (science-related knowledge, understanding, attitudes, behaviours and social contacts);
- Challenge the white, male, middle-class image of science;
- Ensure a more equitable and inclusive science and STEM culture within education systems and STEM organisations.[4.16]

In relation to this last point, *ASPIRES* suggests that actual take-up by disadvantaged young people – be that making use of careers resources or joining a science club – should be carefully monitored, and models based on student self-referral called into question.

There have also been calls for differentiated approaches to young people with different interests and values. Research by the IMechE proposes that STEM engagement and education be tailored to five adolescent 'tribes' it calls: STEM Devotees, Social Artists, Enthused Unfocused, Individualists and the Less Engaged. It recommends giving more encouragement to those who are enthusiastic but currently lacking in confidence, showing a wide range of technologies in engagement activities to appeal to a broader range of young people and highlighting links between capabilities, interest and values and career opportunities.[4.17]

We can also learn from studies investigating problems in career decision-making. The Careers & Enterprise Company has focused on 'choice overload':[4.18]

- Young people are disengaged from thinking about their career because the task is made too difficult. This is caused in part by the difficulty of understanding what different futures would really be like – without which it is hard to be enthusiastic about careers. But it is also, in part, due to the 'high cognitive burden' or 'choice overload' of attempting to make important decisions when it requires the consideration of large amounts of information that are difficult to interpret.
- Instead of informed choice, young people fall back on simple heuristics – eg going to university will mean you can earn more – heuristics that are often based on the advice of parents and family. These 'rules of thumb' and the public understanding of what makes a good career decision are often wrong.
- One barrier to engaging in thinking about careers was the degree to which young people had to go out and seek information. There were few mechanisms that 'pushed' the most relevant information to them. They had little sense that anybody had been able to identify the opportunities open to them and point them towards the issues that mattered.'[4.19]

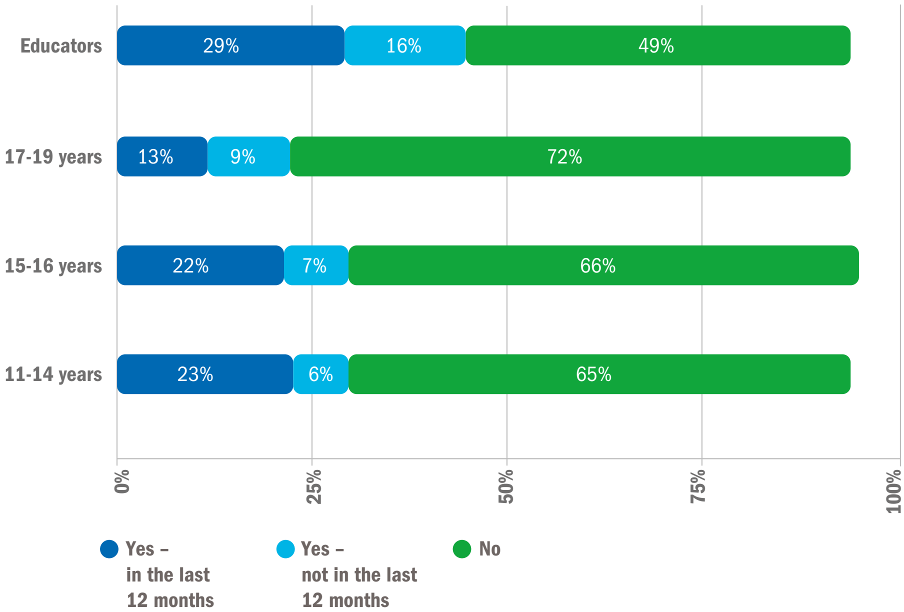
The Careers & Enterprise Company concludes that young people need help to make decisions by giving them a better understanding of what different careers involve and framing decisions in ways that are manageable. It believes this may require simpler, clearer messaging to young people about what matters in career decisions, and a better understanding of how career decisions are made, so that they receive

4.11 King's College London: *ASPIRES 2 Home* (webpage). http://www.kcl.ac.uk/sspp/departments/education/research/ASPIRES/Index.aspx **4.12** King's College London: *ASPIRES 2 responds to inquiry on science communication.* June 2016. http://blogs.kcl.ac.uk/aspires/ **4.13** A T Kearney Inc : *Tough Choices: the real reasons A level students are steering clear of science and maths*, 2016. https://www.atkearney.co.uk/documents/10192/7390617/Tough+Choices.pdf/a7408b93-248c-4b97-ac1e-b66db4645471 **4.14** Your Life: *The Campaign* (web page). http://www.yourlife.org.uk/the-campaign **4.15** King's College London: *Understanding physics and maths participation survey of 14- to 15-year-olds*, 2008. http://www.kcl.ac.uk/sspp/departments/education/research/cppr/Research/pastproj/TISME/Research-Projects/UPMAP.aspx **4.16** King's College London: *ASPIRES 2 responds to inquiry on science communication*, June 2016. http://blogs.kcl.ac.uk/aspires/ **4.17** Institution of Mechanical Engineers: *Five tribes: personalising engineering education*, December 2014. http://www.imeche.org/policy-and-press/reports/detail/five-tribes-personalising-engineering-education **4.18** Careers & Enterprise Company: *Moments of choice: how educational outcomes data can support better informed career decisions*, August 2016; https://s3-eu-west-1.amazonaws.com/cec-app-files-staging/attachments/resources/000/000/007/original/Moments_of_Choice.pdf?1471879058 **4.19** Careers & Enterprise Company: *A response to the moments of choice research*, August 2016; https://s3-eu-west-1.amazonaws.com/cec-app-files/attachments/resources/000/000/007/original/Response_to_Moments_of_Choice.pdf?1472053055

Back to Contents

consistent, constructive advice from adults and are able to navigate their way through the increasingly complex world of employment.

Figure 4.6: Participation in STEM careers activities by 11- to 19-year-olds and educators



Source: EBM 2016

4.2.2 Impact of inspiration activities and employer engagement

A substantial minority of young people have taken part in STEM careers activity. The EBM 2016 showed this to be slightly more common among 11- to 14-year-olds (30%) and at 15-16 (29%) than among 17-19s (22%). Teachers were also more likely than pupils to have done this – 46% of teachers had taken part in a STEM careers activity at some time and 29% had done so within the previous year. Big Bang Near Me was the most attended specific activity in the past twelve months for most pupil age-groups, although the Big Bang Fair and Big Bang Near Me were mentioned by similar proportions of 17- to 19-year-olds and teachers.

The RAEng *UK STEM Education Landscape* report states that most inspiration and enrichment provision takes place in schools and is delivered by specialist STEM organisations to a core audience of 11– to 14-year-olds. ‘Talks and presentations’ are most common, followed by hands-on, extra-curricular activities. However, the most common activities are the least evaluated:

Where it does take place, evaluation is often limited to brief feedback forms undertaken by students or teachers directly after an event… There is therefore a key issue with regards to ascertaining the efficacy of ‘single-activity’ interventions compared with longer-term, sustained interventions, in terms of increasing attainment and progression to STEM education study in post-16 education.[4.20]

The report also highlights the urgent need for better coordination of employer engagement in education, so that all pupils can benefit. Provision is full of overlaps and gaps, with many schools and employers confused as to what opportunities are available and how best to engage. In England, the Careers & Enterprise Company was launched in 2015 with a remit to address such issues. Its key roles are to identify ‘what works’, enable and convene the best programmes, and facilitate more effective, lasting partnerships between schools and local businesses.

EngineeringUK and the RAEng are working together on co-ordination and evaluation within the engineering community. Tomorrow’s Engineers is a programme of co-ordinated schools outreach and careers inspiration, led by engineering businesses, not for profit organisations and charities, that aims to create the next generation of engineers.[4.21] Tomorrow’s Engineers aims to give all young people aged 11 to 14 the opportunity to access at least one engineering experience with an employer, to help them make the connection between school work and career possibilities. Employers within the Tomorrow’s Engineers network have access to an evaluation scheme to help benchmark their outreach activity against national data, work experience guidance and the full range of Tomorrow’s Engineers careers resources.

EngineeringUK is also developing a heat map of engineering careers activities across the country through a national database that provides an accurate picture of what is happening locally.[4.22] This is driven by a database that captures employer outreach activity. Many companies and organisations that are already working with schools are sharing data on that activity to give as comprehensive a picture as possible of current school coverage. As this map develops, it will enable Tomorrow’s Engineers to identify new opportunities and areas of duplication and to work with local employers in the network to reach more schools more efficiently.

4.20 Royal Academy of Engineering: *The UK STEM education landscape*, May 2016. www.raeng.org.uk/stemlandscape **4.21** EngineeringUK: *Tomorrow’s Engineers* (web page). www.tomorrowsengineers.org.uk
4.22 EngineeringUK: *Tomorrow’s Engineers* (web page, see ‘What is the heat map of schools outreach?’). http://www.engineeringuk.com/Tomorrows-Engineers/

4.3 Careers education and guidance

Access to engineering careers requires a well-functioning system of careers education and guidance, not least because of the large number of potential entry routes to the complex engineering domains. Unlike law, medicine or finance, which have relatively simple access routes and recruitment processes, engineering's diversity across many sectors makes it more difficult to navigate. There is a need for young people to understand the progression pathways into engineering, the value of work experience and industrial placements, and the personal and professional characteristics that engineering employers are looking for in both technician-level and graduate entry roles.

Career decision making is a long-term process. Multiple changes of intention (in terms of an identified career direction) are to be expected. In a recent Canadian study, only one in ten young adults (aged 25) had the same career intentions that matched those they held at age 15.[4.23] However, research also points to the positive effects of early careers planning, even where adult employment is unrelated to teenage aspirations.[4.24, 4.25]

Careers terminology

Careers education, for individuals and groups, focuses on career learning, teaching and assessment. It enables learners to understand themselves, get information, explore opportunities and develop the skills they need to manage their careers.

Career(s) guidance, for individuals and small groups, focuses on careers information, advice and support. It may include counselling and coaching. It enables individuals to accomplish the unique tasks and issues they face in making progress and achieving their aspirations.

Careers education and guidance rely heavily on collaborative and partnership activities and interventions between a range of **'careers influencers'**. These include learners themselves, parents and carers, other learning providers, and business and community organisations.[4.26]

Yet a significant minority of the UK's 15- and 16-year-olds have experienced little or no careers support during secondary school. The 2011 Education Act removed the statutory duty of local authorities in England to provide careers information, advice and guidance to young people, placing that duty instead on individual schools and colleges, along with weak statutory guidance. From that point, schools did not receive any specific or additional funding to create or buy in provision to help them discharge these new responsibilities. In Wales, the government-funded organisation responsible for offering free careers advice, Career Choices Dewis Gyrfa (CCDG), has seen its core budget more than halved in the past six years.[4.27] Increasingly, this is limiting provision to priority groups within its face-to-face work in schools.

A 2015 survey of schools in England found that:

- With **careers education** no longer compulsory, up to a third of schools have dropped it from the curriculum, and a larger proportion have no careers education in the early years of secondary education;
- Less than half of schools include **work-related learning** in the curriculum in all years except Year 10, where up to two-thirds of schools organise some activities with employers;
- Many schools are making **impartial career guidance** available to at least those students identified as needing support, but in over 40% of the schools (that responded to this survey) the interviews are not provided by an adviser qualified to QCF level 6;
- Schools are providing a wide range of **employer activities** but many would welcome more support with identifying relevant contacts and organising activities;
- At least half of all schools do not have a middle-level **leader responsible** for career education and guidance, and nearly two-thirds have neither a middle leader nor a senior leader responsible for employer links.[4.28]

These findings dovetail with the reported experiences of 15- to 16-year-old pupils in English schools, less than two-thirds of whom have received careers-related education.[4.29] That research found that appropriate careers education, "is not currently reaching those most in need of it". In general, pupils with high STEM career aspirations and those planning on pursuing apprenticeships were more likely to have experienced career education than the undecided and the socially disadvantaged.

Since 2015, policy changes have brought about some improvement in England: establishing stronger guidelines for schools, national brokering services, and increased employer involvement in all types of careers education. The Department for Education has announced the forthcoming publication of a careers strategy that will develop the government's aims for careers guidance to 2020. Legislation may also be on the cards to require schools to ensure non-academic routes receive "equal airtime" with academic routes in schools career advice.[4.30]

Scotland has launched a new careers education and guidance programme in its schools, described later in this section. This has some increased funding for careers work from the Scottish government. In England, provision for one group of young people is growing: the Department for Work and Pensions is funding additional advice and guidance for 14- to 17-year-olds in danger of becoming NEET. This is being delivered in schools and colleges by new JobcentrePlus employment advisers.[4.31]

The latest (2015) statutory guidance in England, entitled *Careers guidance and inspiration for young people in schools*,[4.32] shows the influence of the 2014 Gatsby report *Good Career Guidance* (including its proposed benchmarks, see Figure 4.7) as well as Lord Young's report *Enterprise for All*.[4.33] Maintaining schools' duty to secure independent careers guidance for all Year 8-13 pupils, the statutory guidance puts particular emphasis on employer engagement. Young people should be exposed to a range of careers first hand. Schools are advised to "build strong links with employers," to offer individual and curriculum-relevant work experience, and to provide access to advice on non-academic options. STEM's importance is singled out: pupils should:

understand that a wide range of career choices require good knowledge of maths and the sciences. Schools should ensure that pupils are exposed to a diverse selection of professionals from varying occupations which require STEM subjects.

4.23 Statistics Canada: *Career decision-making patterns of Canadian youth and associated post-secondary educational outcomes*, (Education Indicators in Canada Fact Sheet 10), 2015. http://www.statcan.gc.ca/pub/81-599-x/81-599-x2015010-eng.htm **4.24** N. Nguyen and D. Blomberg, NCVER: *The role of aspirations in the educational and occupational choices of young people*, (Longitudinal Surveys of Australian Youth, Briefing Paper 29), NCVER 2014. https://www.ncver.edu.au/publications/publications/all-publications/the-role-of-aspirations-in-the-educational-and-occupational-choices-of-young-people **4.25** Australian Sociological Association: *Returns to ambition: The role of early career plans in the transition from education to work*, 2010. https://www.tasa.org.au/wp-content/uploads/2011/01/Sikora-Joanna.pdf
4.26 Association for Careers Education and Guidance: *ACEG framework for careers and work-related education: a practical guide*. www.cegnet.co.uk/uploads/resources/ACEG-Framework-final.pdf
4.27 WalesOnline: *Less than a fifth of pupils in Wales getting careers advice, experts warn*, (web page) March 2016. http://www.walesonline.co.uk/news/education/less-fifth-pupils-wales-getting-11033504
4.28 Career Development Institute (CDI) with Careers England: *Survey of career education and guidance in schools and links with employers*, May 2015. http://www.thecdi.net/write/BP340-Schools_Survey-_FINAL.pdf **4.29** Professor Louise Archer and Dr Julie Moote: *ASPIRES 2 Project Spotlight: Year 11 students' views of careers education and work experience*, King's College London, February 2016. www.kcl.ac.uk/sspp/departments/education/research/ASPIRES/ASPIRES-2-Project-Spotlight---Year-11-Students-Views-on-Careers-Education-and-Work-Experience.pdf **4.30** Robert Long and Sue Hubble: *Careers guidance in schools, colleges and universities*, (House of Commons Library Briefing Paper Number 07236), June 2016. http://researchbriefings.parliament.uk/ResearchBriefing/Summary/CBP-7236#fullreport **4.31** Career Development Institute: *Jobcentre Plus Support for Schools* (Factsheet). http://www.thecdi.net/write/News/News%20via%20Email%20Uploads/JCP_Support_for_schools_fact_sheet_v7.docx **4.32** DfE: *Careers guidance and inspiration for young people in schools: statutory guidance for governing bodies, school leaders and school staff*, March 2015. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/440795/Careers_Guidance_Schools_Guidance.pdf **4.33** Lord Young: *Enterprise for All: the relevance of enterprise in education (the third part of the report on enterprise and small firms)*, June 2014. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/338749/EnterpriseforAll-lowres-200614.pdf

The foundation of the Careers & Enterprise Company has been central to this revised approach to careers education and guidance in England. This government-funded organisation's main purpose (according to the statutory guidance) is to broker relationships between employers and schools and colleges, with the aim of ensuring high quality, work-related inspiration and guidance for more young people aged 12-18. The National Careers Service, which offers information and advice to adults and young people aged 13 and over, also offers some support through contractors that schools can commission. These specialise in areas such as brokering relationships between schools, colleges, local communities and employers, and are backed by Local Enterprise Partnerships (LEPs).

The Careers & Enterprise Company states that it aims to act as a 'catalyst' in the fragmented landscape of careers and enterprise, and to support effective programmes, fill gaps in provision and ensure coverage across the country.[4.34] It has developed a set of ten 'careers and enterprise indicators' for identifying areas of need or 'cold spots.' It provides support for schools and colleges through a network of enterprise advisers: volunteers from businesses and the public sector who work with school and college leaders to build employer engagement plans, drawing on their own local experience. They are supported by full-time coordinators who can advise on the availability of, for example, speakers in schools, or providers of CV- and skill-building advice, or of work experience.

In 2016, a joint parliamentary sub-committee (Business, Innovation & Skills and Education Committees) concluded that much more needs to be done to improve careers provision in England.[4.36] Its recommendations for the government's new careers strategy cover:

- Incentivising schools: "Ofsted's role should be strengthened, and schools downgraded if careers provision is not *effective*";
- Streamlining careers provision: a single minister in charge, rationalisation of government-funded organisations, strengthening the Careers & Enterprise Company's role as an umbrella body, ("steps…to bring order to the congested market place of service providers and websites"), and a single brand of standards;
- Grounding careers advice and guidance in good quality labour market information, Local Enterprise Partnerships should have the capacity, and be encouraged, to provide this to schools, colleges and careers professionals;
- The need for all young people to engage with employers and have meaningful work experience.

Figure 4.7: Gatsby benchmarks.[4.35]

1 A stable careers programme
Every school and college should have an embedded programme of career education and guidance that is known and understood by students, parents, teachers, governors and employers.

2 Learning from career and labour market information
Every student, and their parents, should have access to good quality information about future study options and labour market opportunities. They will need the support of an informed adviser to make best use of available information.

3 Addressing the needs of each student
Students have different career guidance needs at different stages. Opportunities for advice and support need to be tailored to the needs of each student. A school's careers programme should embed equality and diversity considerations throughout.

4 Linking curriculum learning to careers
All teachers should link curriculum learning with careers. STEM subject teachers should highlight the relevance of STEM subjects for a wide range of future careers paths.

5 Encounters with employers and employees
Every student should have multiple opportunities to learn from employers about work, employment and the skills that are valued in the workplace. This can be through a range of enrichment activities including visiting speakers, mentoring and enterprise schemes.

6 Experiences of workplaces
Every student should have first-hand experiences of the workplace through work visits, work shadowing and/or work experience to help their exploration of career opportunities, and expand their networks.

7 Encounters with further and higher education
All students should understand the full range of learning opportunities that are available to them. This includes both academic and vocational routes and learning in schools, colleges, universities and in the workplace.

8 Personal guidance
Every student should have opportunities for guidance interviews with a career adviser, who could be internal (a member of school staff) or external, provided they are trained to an appropriate level. These should be available whenever significant study or career choices are being made. They should be expected for all students but should be timed to meet their individual needs.

Source: The Gatsby Trust

Scotland has an all-age approach to children and young people's careers education. Its new programme of career education started during the 2015/16 school year. Elements include: career management skills and learning about careers and work as part of the school curriculum; the careers portal My World of Work;[4.37] drop-in clinics; one-to-one career coaching on a needs basis and for those making subject choices; the presence of Skills Development Scotland careers advisers at parents' evenings; group sessions with Skills Development Scotland careers advisers; and group sessions on current and future labour markets.[4.38] Individual advice and guidance for lower secondary pupils before they choose examination subjects is being trialled in 35 'early adopter' schools.[4.39] Information has also been targeted at parents to help them support their children's learning about the world of work.[4.40]

Scottish policy also has a strong focus on employer engagement, according to the report of the Commission for Developing Scotland's Young Workforce in 2014.[4.41, 4.42] In autumn 2015, guidance and standards were published, following a development process led by Skills Development Scotland, in partnership with Education Scotland, the Scottish government and other relevant national bodies. These comprise:

- Guidance on School/Employer Partnerships – highlights the benefits of meaningful and productive partnerships, including employability skills, and suggests practical steps for both employers and schools;
- Career Education Standard (3-18) – recognises the journeys all children and young people make as they learn about the world of work from the early years to the senior phase;
- Work Placements Standard – recognises the rich learning that all young people can experience when they use and develop their skills in a work environment.[4.43]

A review of progress on implementation will take place to measure their impact (spring 2017).

Northern Ireland has also reviewed its careers provision and made policy commitments related to an accountability and quality assurance framework; e-delivery and labour market information; work experience; accessing impartial advice; and developing e-portfolios.[4.44] Changes will include a new statutory duty to ensure that individuals can access "impartial careers support from appropriately qualified practitioners" and developing support for parents as well as that provided to young people.

In Wales, strategic planning by Careers Choices Dewis Gyrfa has been put on hold pending a change of government.[4.45]

4.34 The Careers & Enterprise Company: *Moments of choice: how education outcomes data can support better informed career decisions*, August 2016. https://s3-eu-west-1.amazonaws.com/cec-app-files-staging/attachments/resources/000/000/007/original/Moments_of_Choice.pdf?1471879058 **4.35** The Gatsby Trust: *Good career guidance*, May 2014. http://www.gatsby.org.uk/education/programmes/good-career-guidance **4.36** House of Commons: *Careers education, information, advice and guidance*, First Joint Report of the Business, Innovation and Skills and Education Committees of Session 2016–17, July 2016. https://www.publications.parliament.uk/pa/cm201617/cmselect/cmese/205/205.pdf **4.37** Skills Development Scotland: *My world of work* (website). https://www.myworldofwork.co.uk/ **4.38** The National Parent Forum of Scotland: *Career Education: A World of Possibilities*. https://www.educationscotland.gov.uk/Images/NPFS_world_of_possibilities__tcm4-874397.pdf **4.39** Details of implementation of Scotland's new careers education programme at: http://www.sfc.ac.uk/web/FILES/CMP_SDSSFCJointSkillsCommittee5November2_05112015/SC_15_21_DYW_-_Career_Education_Standard_update.pdf **4.40** The National Parent Forum of Scotland: *ibid* **4.41** Commission for Developing Scotland's Young Workforce: *Education Working For All!*, June 2014, pp8-10. http://www.gov.scot/resource/0045/00451746.pdf **4.42** Scottish government: *Developing the Young Workforce: Scotland's Youth Employment Strategy*, December 2014. http://www.educationscotland.gov.uk/Images/DYWResponseYouthEmpl%20Strategy_tcm4-853595.pdf **4.43** Skills Development Scotland: *New guidance to support Developing the Young Workforce,* (web page), 2015. https://www.skillsdevelopmentscotland.co.uk/news-events/2015/september/new-guidance-to-support-developing-the-young-workforce/ **4.44** DELNI & DENI: *Preparing for success 2015-2020, a strategy for careers education and guidance*, March 2016. http://dera.ioe.ac.uk/25594/3/Careers%20Strategy%20(web)_Redacted.pdf **4.45** Welsh government: *Career Choices Dewis Gyrfa (Ccdg): Remit and Priorities 2016-17* (letter), 2016. http://gov.wales/docs/dcells/publications/160330-ccdg-remit-letter-2016-17-en.pdf

4.4 Workplace experience

Lack of work-readiness among young people is widely thought to have a major impact on their future. According to the Education and Employers Taskforce, they face:

record levels of rejection from employers. Over the last generation, the ratio of youth to adult unemployment has doubled, meaning that young people are now some four times more likely to face unemployment than workers over 24.[4.46]

This was based on research conducted with recruiters which highlighted three significant structural changes in the youth labour market: its growing complexity, the increasingly fractured character of school-to-work transitions, and the evolving requirements of employers. Recruiters believed that the distance between the classroom and the workplace had grown too large and regretted the relative decline in popularity of part-time work amongst teenagers (ie a 'Saturday job'). They felt that schools were unable to put in place sufficient employer engagement for teenagers to make up for that loss of experience of paid work.

City & Guilds *Great Expectations*[4.47] survey found that a quarter of 14- to 19-year olds had no workplace experience at all and only a quarter had any paid work experience (part-time, vacation and casual work). Half had completed a short work experience placement arranged through school or college and one in ten had done work shadowing. Voluntary work was a significant form of work experience for young women (one third), but only for one in five young men. Fewer than one in twenty young people had worked in a full-time paid job or an extended placement. Other studies have also revealed significant regional differences in young people's access to work experience placements.[4.48, 4.49]

Research by the Education and Employers Taskforce for the Edge Foundation has shown that students aged 16-17 who have part-time work are more likely to be in work at the age of 18-19, and are also less likely to be NEET five years later.[4.50, 4.51] Research has also shown that graduates with work experience tend to get better degrees, higher wages and are less likely to be unemployed.[4.52] Yet the City & Guilds study referred to earlier found that only 28% of 14- to 19-year-olds thought that previous work experience was one of the most important factors for getting a job.

Employers take the reverse view. In another survey for City & Guilds,[4.53] 78% of employers judged work experience essential to ensuring young people are ready for work and 67% would be more likely to hire a young person with work experience over someone with none.

In the same way, the UK Commission for Employment and Skills (UKCES) has found that work experience is a critical or significant recruitment factor for 66% of employers – more than the candidate's particular level of academic attainment (49%) and relevant vocational qualifications (50%).[4.54] However, it reports that the proportion of employers offering work experience placements to people in education is just 30% (while 20% engage with schools and 12% with FE colleges). The report paints a picture of young people "caught in a Catch-22 situation… finding it difficult to get work without experience and difficult to obtain experience without work." It urges employers to open up their workplaces to more young people.

When it comes to recruiting STEM-skilled staff, the *CBI/Pearson Education and Skills Survey* has found that 46% of employers viewed a lack of general workplace experience as a barrier to recruitment, while 44% cited a lack of appropriate attitude and aptitudes for working life.[4.55] The *ASPIRES* research into careers education and work experience also found that 15- to 16-year-olds aspiring to STEM careers were among those least likely to have had work experience.[4.56] This survey found that work experience was more often organised by parents and families than by schools. This meant that students from socially-advantaged families were more likely to have access to high-quality work experiences and placements, and that access by disadvantaged students to STEM placements was limited.

While some authorities and schools view work experience placements as primarily for improving general employability skills (particularly at age 14-15), and persist with a standalone week- or fortnight-long 'immersion' model, others are seeking to enhance the role of work experience in developing career thinking. This is leading to some more flexible and personalised models for gaining workplace experience. One is Education Scotland's Work Placement Standard, which emphasises that:

a wide variety of models need to be considered in order to ensure a more individualised approach. This ranges from providing a number of bite-size placements through to extended placements. These may sit within the conventional school week or outwith it as appropriate.[4.57]

Another is when work placements are sometimes combined with other forms of contact with the world of employment. For example, the London Ambitions Careers Offer calls for local councils and schools to enable at least 100 hours' experience of the world of work for every young Londoner, which may include career insights from industry experts, work tasters, coaching, mentoring, enterprise activities, part-time work, participation in Skills London and the Big Bang Event, work shadowing, work experience or supported work experience and other relevant activities. It states that these experiences should be recorded in a 'personalised digital portfolio' with the aim that young people take responsibility for capturing their learning and experiences and the support for their careers activities with employers."[4.58]

4.46 Education and Employers Taskforce: *What do recruiters think about today's young people? Insights from four focus groups*, (Anthony Mann and Prue Huddleston, Occasional Research Paper 5), September 2015. http://www.educationandemployers.org/wp-content/uploads/2015/09/What-do-recruiters-think-about-todays-young-people-September-2015-003.pdf **4.47** City & Guilds: *Great expectations: teenagers' aspirations versus the reality of the job market*, 2015. http://www.cityandguilds.com/~/media/Documents/Courses-and-Quals/Apprenticeships/EMSI%20reports/cggreatexpectationsonline%20pdf.ashx **4.48** UKCES: *Geographical variation in access to work placements and work inspiration: data from the Employer Perspectives Survey 2014*, February 2015. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/404998/15.02.18._Commentary_V10.pdf **4.49** Professor Louise Archer and Dr Julie Moote: *ASPIRES* 2 Project Spotlight: *Year 11 students' views of careers education and work experience*, King's College London, February 2016. http://www.kcl.ac.uk/sspp/departments/education/research/ASPIRES/ASPIRES-2-Project-Spotlight---Year-11-Students-Views-on-Careers-Education-and-Work-Experience.pdf **4.50** Education and Employers Taskforce: *Profound employer engagement in education: What it is and options for scaling it up*, October 2013. http://www.educationandemployers.org/wp-content/uploads/2014/06/profound_employer_engagement_published_version.pdf **4.51** DWP: *Work experience: a quantitative impact assessment*, March 2016. https://www.gov.uk/government/publications/work-experience-a-quantitative-impact-assessment **4.52** UKCES: *Climbing the ladder: skills for sustainable recovery*, July 2014. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/378968/Summer_What_0v41.pdf **4.53** City & Guilds: *Making education work: preparing young people for the workplace*, October 2013; http://www.cityandguilds.com/~/media/Documents/Courses-and-Quals/quals-explained/techbac/making-education-work%20pdf.ashx **4.54** UKCES: *Catch 16-24: youth employment challenge*, February 2015; www.gov.uk/government/uploads/system/uploads/attachment_data/file/404997/15.02.18._Youth_report_V17.pdf **4.55** CBI: *Inspiring Growth: CBI/Pearson education and skills survey 2015*, May 2015. http://www.cbi.org.uk/insight-and-analysis/inspiring-growth-the-education-and-skills-survey-2015/ **4.56** Professor Louise Archer and Dr Julie Moote: *ibid* **4.57** Education Scotland: *Developing the young workforce: work placements standard*, September 2015, p4. https://www.educationscotland.gov.uk/Images/WorkPlacementStandard0915_tcm4-870517.pdf **4.58** London Enterprise Panel, London Councils and Mayor of London: *London ambitions: shaping a successful careers offer for all young Londoners*, June 2015. https://www.london.gov.uk/sites/default/files/shaping_report_interim_19_june_sp.pdf

4.5 Diversity and the talent pool

The Royal Academy of Engineering has demonstrated, through a case study toolkit, the business benefits of a more diverse workforce, beyond the obvious goal of this being helpful in addressing the engineering skills gap. Those benefits potentially include positive impact on an organisation's financial performance, greater innovation and creativity, increased employee productivity and retention, improved customer or client orientation, and increased customer or client satisfaction.

In terms of gender, the baselines within the supply chain of STEM skills make daunting reading. Under a quarter of girls' entries to A levels are in maths and sciences, compared with almost four in ten for boys. Although female students are the majority at university, they make up only around 14% of first degree students in engineering, and 8% of professional engineers once in the workforce.[4.59] Gender segregation is particularly extreme among school-leavers taking up apprenticeships. In Chapter 6, we discussed the government's Post-16 Skills Plan, which is its current vision for technical education in England. This points out that nearly 9,000 level 2 apprenticeships in hairdressing were started by women in 2013/14, but only 80 at the same level in engineering.[4.60]

The engineering community's focus on the gap between male and female perceptions of, and participation in, engineering has been extensive. Perhaps less well studied has been the low participation by other groups that form a small minority in engineering. It has been suggested that a challenge for engineering is to understand the values and aspirations of different groups of younger people and to align its messages so that it is seen as a discipline and a career that resonates with more young people, and comes to be seen as a profession 'for people like me'.[4.61]

ASPIRES research suggests that part of the problem is inequality within careers provision at school – not just across, but also within, individual schools. It claims that pupils who are female, of ethnic minority background, working-class, lower-attaining and also those who are unsure of their aspirations or plan to leave education post-16, are all significantly less likely to say that they have received careers education.[4.62] The report recommends that policy needs to focus on participation in careers education and not just its provision, to ensure that it reaches under-served groups of pupils or communities. It also states that greater effort is needed on the part of educators and careers services to monitor uptake and engage those who are not participating in careers and work experience provision.

Various parts of the engineering community have been implementing broader strategies for diversity and inclusion. The Royal Academy of Engineering describes a range of actions to 'understand and remove barriers to diversity and inclusion'.[4.63] These include:

- Activities aimed at school level, such as a project to make it easier for ethnic minority groups to engage with, and get inspiration from, role models from similar backgrounds;
- A good-practice guide for recruiting female and BME apprentices;
- Development of sign language for deaf people studying physics and engineering to enable teachers of deaf pupils to use consistent vocabulary to interpret physics.

4.5.1 Gender stereotyping

The engineering talent pool experiences the particular problem that too few girls choose to study physics post-16. In Section 5.9 of this publication, the Institute of Physics (IoP) reports in detail on some of its recent initiatives to encourage a greater proportion to girls to pursue physics at A level. This is important because while the overall number of A level physics entrants has risen by 17% between 2010 and 2015, there has been little change to the proportion of girls taking the subject (around 21%). Both the IoP's work and research with 15- and 16-year-olds and parents in the *ASPIRES* project have found two key issues in relation to choosing physics post-16:

- Representations of women in physics, both in reality and in popular media, are rare, creating an impression that physics is a subject for men;
- It is seen as a 'hard' subject – and 'hard' subjects tend to be seen as 'for men'.

This reflected the concern expressed by some girls interviewed who didn't want to continue with physics post-16 because of a fear of being "the only girl in the class", but also that some teachers presented A level physics as a subject for which a "boy brain" was needed.[4.64]

In Section 5.9, the IoP demonstrates how certain approaches to changing the environment on a whole-school basis can have an important influence on this key subject choice. The IMechE also emphasises the need to reposition engineering as a people-focused, problem-solving, socially-beneficial discipline, to appeal to a broader range of young people. It suggests that engineering has traditionally focused on nouns – ie its products – whereas communicating what engineers do needs a focus on verbs. A greater emphasis on adjectives could also help engineering appeal to girls, as could stressing some of the aspects of engineering work – teams, creativity, impacts – that may resonate more with them.[4.65]

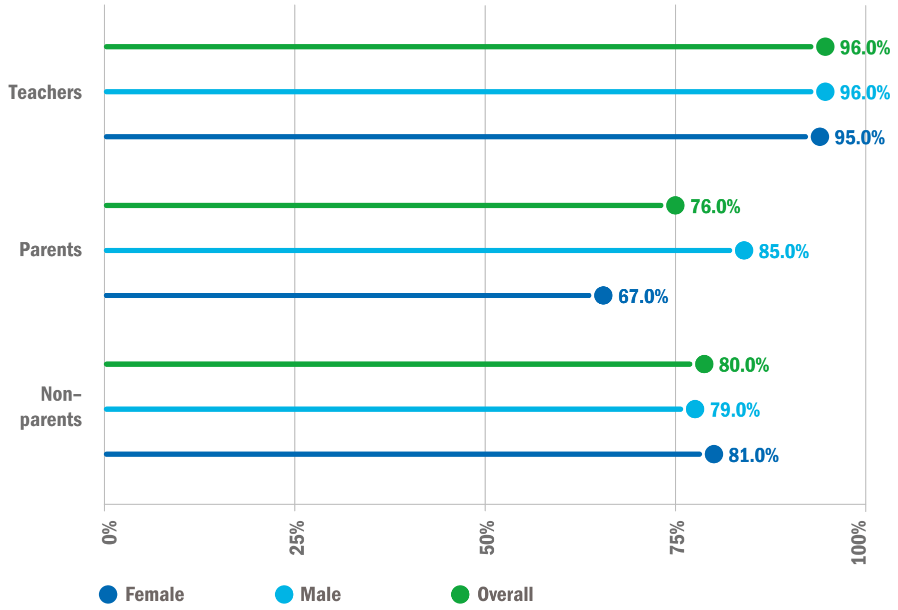
The EBM 2016 also shows the persistence of gendered attitudes towards engineering careers among parents. This relates to both the gender of the parent and the gender of their child(ren):

- Male parents were more likely to agree that a job in engineering would be interesting, and that they see lots of examples of engineering in everyday life;
- Male parents were more likely than female parents to agree that engineers make a good contribution to society, that engineers will have a positive impact on our future and/or that being an engineer is a well-respected profession – similarly, parents of male children were more likely than parents of female children to agree that engineers make a good contribution to society, that being an engineer is a well-respected profession, and that people know what engineers do;
- Female parents were less likely than male parents to say they would recommend an engineering career to their children (67% compared to 85%) – the same is true of parents of female children, compared to those with male children (74% and 81%, respectively), while female non-parents and teachers are more likely to recommend engineering careers (Figure 4.8).

The importance of better communication with parents has been highlighted in the recent national careers education strategies of Scotland and Northern Ireland.[4.66] One important aspect in career communication is improving parents' understanding of subject choice. As shown in Table 4.3, a significant minority of parents (and female more than male parents) do not recognise the importance of physics for careers in engineering. Knowledge levels of the importance of mathematics could also be improved among parents, and of physics among teachers.

4.59 Royal Academy of Engineering: *Increasing diversity and inclusion in engineering – a case study toolkit,* (Diversity Leadership Group) 2015. http://www.raeng.org.uk/policy/diversity-in-engineering/diversity-and-inclusion-toolkit/documents/increasing-diversity-and-inclusion-in-engineering **4.60** DfE and BIS: *Post-16 skills plan,* July 2016. https://www.gov.uk/government/publications/post-16-skills-plan-and-independent-report-on-technical-education **4.61** Institution of Mechanical Engineers: *Big ideas: the future of engineering in schools*, 2016. https://www.imeche.org/policy-and-press/reports/detail/big-ideas-report-the-future-of-engineering-in-schools **4.62** Professor Louise Archer and Dr Julie Moote: *ibid* **4.63** Royal Academy of Engineering: *Diversity Programme Report 2011–2016*, May 2016. www.raeng.org.uk/publications/reports/diversity-programme-report **4.64** Emily MacLeod: *Who says you need a 'boy brain' to do Physics?* (APIRES 2), September 2016. http://blogs.kcl.ac.uk/aspires/who-says-you-need-a-boy-brain-to-do-physics **4.65** Institution of Mechanical Engineers: *Big ideas: the future of engineering in schools*, 2016 **4.66** DELNI & DENI: *Preparing for success 2015-2020, a strategy for careers education and guidance*, March 2016; http://dera.ioe.ac.uk/25594/3/Careers%20Strategy%20(web)_Redacted.pdf

Figure 4.8: Whether adults would recommend an engineering career to young people/their children/pupils: general public and teachers (2016)



Source: EBM 2016

Table 4.3: Key subjects needed to become an engineer: subjects selected by teachers and parents (2016)

		Maths	Physics	Engineering	Design and technology	English
Teachers:	**overall**	95%	85%	42%	39%	27%
	male	96%	86%	47%	47%	29%
	female	94%	84%	37%	33%	25%
Parents:	**overall**	84%	64%	73%	50%	42%
	male	88%	72%	79%	53%	41%
	female	80%	56%	68%	48%	43%

Source: EBM 2016

4.5.2 Tackling unequal participation

Policy continues to develop to tackle the shortfall of women in STEM careers – not least because the over-representation of women in non-technical jobs has an impact on the gender pay gap. In England, the Government Equalities Office announced in February 2016 its ambition to see 15,000 more entries by girls to mathematics and sciences by 2020 (a 20% increase on current numbers). It cited a gender pay gap in sectors such as engineering and also the need to tackle the root causes that hinder girls from entering careers in 'these well-paid sectors.'[4.67] In the previous year's statutory guidance on careers, schools were instructed to emphasise the opportunities opened up for girls and boys who choose science subjects at school and college by exposing students to, "a diverse selection of professionals from varying occupations which require STEM subjects". Schools were reminded of "the need to do this for girls, in particular, who are statistically much more likely than boys to risk limiting their careers by dropping STEM subjects at an early age careers."[4.68]

Meanwhile, a recent report commissioned by the Welsh Assembly also calls for strong action. It recommends that:

relative progression of girls in STEM should be monitored...significant under-adoption by girls in any individual school should be investigated, to identify reasons and remedies for any identified problems. Estyn[4.69] should consider any special measures they might impose for this issue.[4.70]

The Careers & Enterprise Company is tasked with investing in careers and enterprise provision in England where support is most needed, and has developed ten indicators to identify areas where access to provision is most problematic. The indicators, shown below, include several specifically relating to choices post-16, one of which is girls' take-up of STEM subject A levels, as well as indicators of social disadvantage:

- % of employers offering work experience;
- % of employers offering work inspiration;
- % of 17- to 18-year-olds poorly prepared for work (employer reported);
- % of 16-year-olds poorly prepared for work (employer reported);
- % of 16- to 17-year-olds who are NEET;
- % of 18-year-olds on apprenticeships;
- % of A levels taken that are in STEM subjects;
- % of STEM A levels taken by women;
- % of pupils gaining 5 GCSEs at grades A*-C;
- % of pupils entitled to free school meals.[4.71]

4.67 Government Equalities Office press release, 12 February 2016; www.gov.uk/government/news/nicky-morgan-nowhere-left-to-hide-for-gender-inequality **4.68** DfE: *Careers guidance and inspiration for young people in schools: Statutory guidance for governing bodies, school leaders and school staff*, March 2015 **4.69** The education and training inspectorate for Wales **4.70** Welsh government: *Talented women for a successful Wales, a report on the education; recruitment; retention and promotion of women in STEM-related study and careers*, March 2016; http://gov.wales/topics/science-and-technology/science/women-in-science/?lang=en **4.71** Careers Enterprise Company: *Prioritisation Indicators*, October 2015. https://www.careersandenterprise.co.uk/research/prioritisation-indicators-2015-cold-spots

Several STEM-focused programmes thought to have particular appeal for girls are among the projects that Careers & Enterprise Company funding has been released to:

- Cogent's Skills Futures in Science: inspiring young people to pursue science careers;
- Engineering Development Trust's Industrial Cadets: raising awareness of and aspiration to local STEM jobs;
- EngineeringUK's Tomorrow's Engineers: helping young people understand the diverse careers available;
- Greenpower Education Trust: student teams design, build and race electric kit cars;
- Solutions for the Planet: challenging pupils to find a business solution to sustainability issues.

4.5.3 Long-term goals

Some have concluded that existing approaches to tackling the impending skills crisis in engineering do too little to challenge the root causes of a lack of diversity during UK education, and have called for a major rethink on how engineering is presented and taught in schools. A report commissioned by the RAEng identifies six engineering habits of mind[4.72] which, taken together, describe the ways engineers think and act. It makes the case that if the UK wants to produce more engineers, it needs to redesign the education system so that these habits of mind become desired outcomes of engineering education.[4.73]

The IMechE report *Big ideas: the future of engineering in schools* is more ambitious still. It identifies a lack of 'engineering literacy' as a national problem, suggesting that schools increase the number and breadth of young people able to choose engineering careers, but also empower those who do not.[4.74] It recommends creation of a more engineering-literate population which has a greater appreciation of engineering, equipped with improved professional and personal problem-solving skills. This more literate population would constitute a larger pool from which future engineers could be drawn.

4.6 The long-term economic impact of careers interventions

Written by Elnaz Kashefpakdel, Education and Employers Taskforce

This article is summarised from a paper published in the *Journal of Education and Work*,[4.75] which examines the relationship between careers talks that British teenagers were exposed to at the ages of 14-15 and 15-16 and their later earnings at age 26. This was an unusual study because, despite the notable policy focus on delivery of careers guidance and education in schools, research on its impact has been limited. The study builds on related research,[4.76] based on a survey of young adults aged 19-24 recalling their school days. This found a significant wage premium linked to the extent of exposure they had as young people to school-mediated employer engagement activities.

This new study uses the British Cohort Study (BCS70), which follows people from birth through their lives into adulthood, tracking some 17,000 individuals. It provides a rich and reliable set of measurements, including socio-economic factors that could potentially affect income, ie parental social class, academic ability, home learning environment and demographics. Using statistical analysis, it is possible to take account of these factors in assessing the impact of specific interventions in determining economic outcomes.

Participants in the BCS70 were teenagers in the mid-1980s, when the Technical and Vocational Education Initiative (TVEI) was being rolled out across the UK. TVEI aimed to help prepare young people better for entry into the labour market. It provided investment which led to many schools introducing changes to broaden the curriculum, making it more relevant to the working world. This also placed a clear emphasis on careers education. When the BCS questioned teenagers in 1986, it provided a snapshot of their school experiences at a time when considerable interest and resource was focused on young people's relationships with the labour market but while there were still high variations in pupil experiences. Pupils aged 16 were asked if they had school-organised contacts with the world of work through work experience, careers talks or workplace visits. Those who had participated in at least one careers talk by a speaker from outside school were asked how many they had attended in Fourth Year (current Year 10, aged 14-15) and Fifth Year (current Year 11, aged 15-16). As can be seen in Figure 4.9, two thirds had participated in at least one such talk.

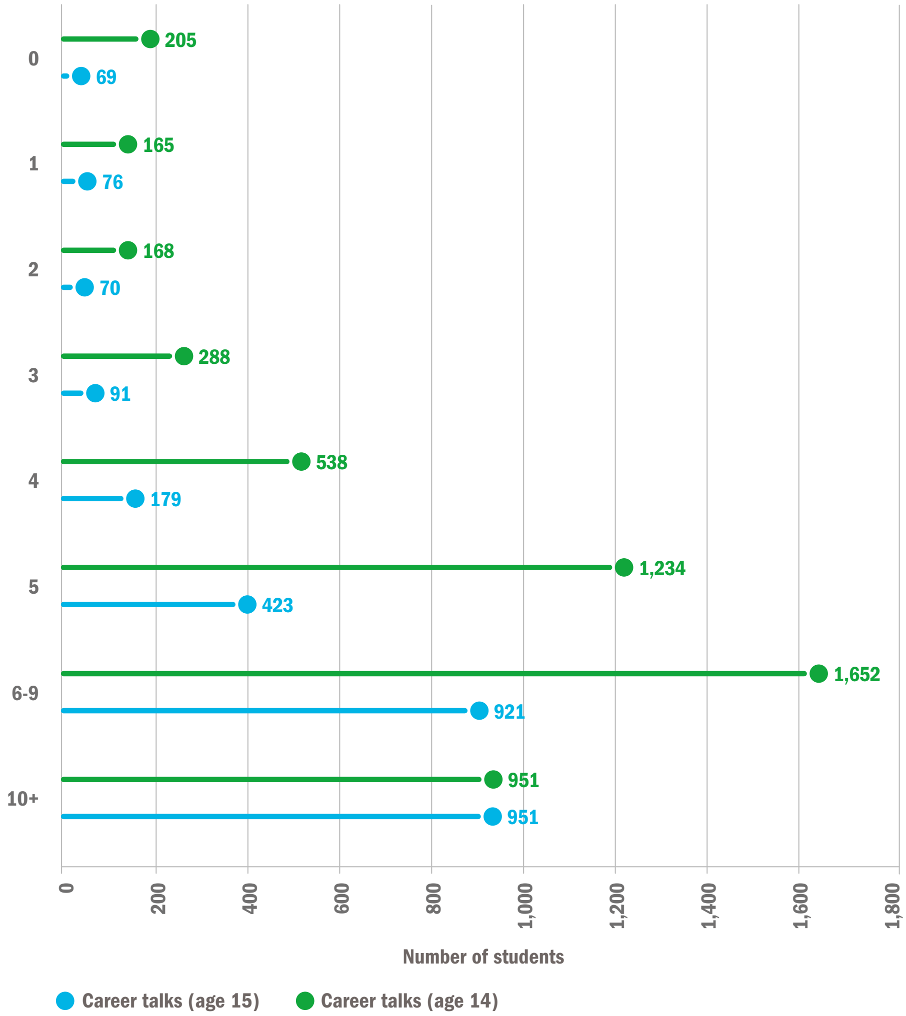
Statistical analysis was used on this data to test the hypothesis that each additional careers talk students encountered would be associated with higher wages at age 26. Only those in full-time employment as adults were included in the analysis, as these respondents were deemed to have fully transitioned into the labour market. (Those in part-time employment could still be in transition from education to work.)

The results revealed that, on average, each career talk by someone outside the school that a 14- or 15-yeaer-old experienced led to a 0.8% wage premium when they were aged 26. These

4.72 1. Systems thinking 2. Adapting 3. Problem-finding 4. Creative problem-solving 5. Visualising 6. Improving. **4.73** Professor Bill Lucas, Dr Janet Hanson, and Professor Guy Claxton, Centre for Real-World Learning at the University of Winchester: *Thinking like an engineer: implications for the Education System*, May 2014. www.raeng.org.uk/publications/reports/thinking-like-an-engineer-implications-full-report **4.74** Institution of Mechanical Engineers: *Big ideas: the future of engineering in schools*, April 2016. https://www.imeche.org/policy-and-press/reports/detail/big-ideas-report-the-future-of-engineering-in-schools **4.75** E. Kashefpakdel and C. Percy: *Career education that works: an economic analysis using the British Cohort Study* (Journal of Education and Work), April 2016. http://dx.doi.org/10.1080/13639080.2016.1177636 **4.76** A. Mann and C. Percy: *Employer engagement in British secondary education: wage earning outcomes experienced by young adults*, (Journal of Education and Work 27 (5) 496–523), 2013. http://www.tandfonline.com/doi/abs/10.1080/13639080.2013.769671

Back to Contents

Figure 4.9: Number of students from the British Cohort Study who had taken part in different numbers of careers talks (1986)



Source: Journal of Education and Work [4.75]

findings were statistically significant, so there is 95% certainty that this correlation did not occur by chance. This relationship was not found for those aged 15-16, which implies that career talks had a greater value for the younger cohort.

Analysis also found a statistically significant relationship between student perceptions of the career talks that they had experienced and their later earnings. Students who found career talks to have been 'very helpful' at age 14-15 were compared with those who found careers talks 'not at all helpful/not very helpful'. This demonstrated that students aged 14-15 who found career talks 'very helpful' witnessed a 1.6% increase in earnings per career talk that they had attended. This also proved significant for young people aged 15-16, who benefited from a 0.9% earnings boost. The students who had deemed talks to be 'very helpful' had on average also experienced more career talks (average 3.4) in comparison with those who had found career talks unhelpful (average 2.2 career talks). This suggests, perhaps unsurprisingly, that students attended more talks if they found them helpful.

The results demonstrate a clear association between the number of career talks attended by young people and their relative earnings at age 26. The impact of the careers talks was more pronounced for the younger age group, 14-15, than for the elder group (15-16). It is likely that the older age group may have been more focused on their examinations, while the younger group could have been more receptive to career talks. This may be because the younger year group was less focused on exam preparation.

Rather, they were in a more explorative period, when they might have found it easier to translate insights from an external speaker to their post-16 decisions.

Previous research has suggested that many career decisions post-compulsory education are influenced by social capital, which is built not only through social background but periods of work experience. We suggest from this study that value can also be gained from quite fleeting interactions with the world of work, ie talks by speakers from outside school. The findings are in line with the argument that young people are able to find helpful information about pathways to their career ambitions through planned encounters with people from the world of work.

We are aware of several caveats in these assumptions. A further analysis using earnings at a later career stage, when respondents are more established in the labour market, would test whether the relationship between careers talks and improved earnings continues through their lifespan. The role of the school the young people attended was not included in the analysis, due to the limitations of the dataset, but could potentially provide useful insights for comparison between different school types. Other measures of employment success besides earnings, such as perceived career satisfaction, could also be examined in the future.

Part 2 - Engineering in Education and Training
5 Secondary education

Key points

The secondary education landscape continues to be complex. It is rife with policy-driven changes to structures (especially in England) and qualifications (across the UK nations). In August 2017, GCSE examinations in England will be graded 9 to 1 (replacing A*-G). Some of the liberalisation of school types in England is allowing new types of school, such as university technical colleges (UTCs), which can be technically-oriented towards fields like engineering. However, these models remain small and are, as yet, largely untested beyond the short term.

GCSE entries

- Following a period of decline, entries to single science GCSE examinations have increased recently – despite a falling teenage population;
- Entries to design and technology and ICT are falling fast, but there is a rise in the number studying computing at GCSE.

GCSE pass rates

- The GCSE pass rate fell in 2016. This is likely to be due indirectly – in part at least – to recent changes in the way that the performance of English schools is measured;
- Pass rates continue to be much higher in single science subjects than in combined science examinations, reflecting the different types of schools and pupils that take these subjects;
- Girls are out-performing boys more and more and white working class boys are amongst the weakest performers academically.
- Ethnic minorities make up a steadily growing proportion of the cohort at this age – Chinese origin pupils were the highest achieving ethnic group while those from black ethnicities were the lowest achieving group.

A level entries

- Entries to science and mathematics at A level are rising, with proportionally greater rises in computing and further mathematics (albeit from smaller numbers);
- The rate of increase is slightly greater amongst females than males, but female students remain in the minority in computing, physics and further mathematics especially;
- It will be important to monitor whether removal of standalone AS level qualifications has any impact on numbers studying STEM subjects post-16.

A level pass rates

- There has been a slight dip in numbers passing A levels in science subjects, largely due to a decreasing cohort size, with the fall in physics and mathematics passes almost entirely from male students;
- Physics continues to have a lower pass rate than many subjects, despite chemistry and further mathematics being proven to be academically more challenging;
- Results trends in Wales and Northern Ireland differ slightly from England, while in Scotland new qualifications are only now bedding in so trends are hard to discern.

BTEC and vocational qualifications

- The number of BTEC and similar vocational qualifications taken in addition to or instead of A levels has risen fast in recent years, and has powered much of the increase in entry to university by those from less advantaged backgrounds;
- The number of young people studying engineering and ICT at level 3 has risen to the point where it is now broadly similar to the number taking A level subjects like physics or computing.

Teaching

- Teacher shortages continue across the four nations, especially in physics, further mathematics and computing, and are most strongly felt in schools teaching combined sciences, not separate sciences;
- The number of mathematics teachers has risen slightly, perhaps in response to recent incentive schemes;
- Whilst the number of entries to GCSE sciences has grown over the last five years, the number of science teachers has fallen;
- The number of design and technology and ICT teachers is falling fast but the cohorts studying them are shrinking too;
- Computing has been recognised recently as a particular problem the government is proposing to add it to the 'shortage occupation list' along with mathematics, chemistry and physics teachers, enabling easier immigration of such professionals to the UK;
- On the plus side, a growing proportion of those teaching science subjects have either a degree in the subject or have had specific training in teaching the discipline.

5.1 Context

Engaging and retaining the interest of 14- to 19-year-olds during Key Stages 4 and 5 of their secondary education is crucial to the future success of the engineering sector in the UK. It is vital that they have access to excellent teaching, effective careers guidance, high quality qualifications and inspirational role models. As the Royal Society has put it:

Science is at the heart of modern life and essential to understanding the world. Along with maths and computing, it equips young people to prosper in today's rapidly-changing, knowledge-focused economies.[5.1]

The Wellcome Trust also continues to want "more students to study more science for longer".[5.2] Commenting on the 2016 A level results, Professor Sir John Holman, Wellcome's education adviser, said:

We need to better understand the factors that are affecting both A level choices and the attainment of the pupils taking science courses, because the country cannot afford a decline in the science base at this critical time for the economy.[5.3]

This statement also quoted Prime Minister Theresa May's reassertion of the government's commitment to science and the high priority it attaches to teaching and research:

Increasing the number of pupils studying science A levels must be a priority for the government, and securing the opportunity for all pupils to be able to study science at A level with excellent teachers is key to reaching this goal.

However, meeting these aspirations remains challenging, not least because of what the Royal Academy of Engineering calls the "the myriad entry routes to the complex engineering domains", which make providing effective information, advice and guidance difficult.[5.4] The engineering sector is active in debating how change might be effected, and making recommendations for policy change, including a range of broad ideas proposed by the Institution of Mechanical Engineers' report *Big Ideas: The Future of Engineering in Schools*.[5.5]

5.1.1 The secondary landscape

Within the English secondary education landscape there are now many more secondary academies than other secondary schools (65% versus 35%).[5.6] The continuing evolution of this landscape in England is potentially providing scope for schools – and therefore students – to specialise in STEM subjects and get hands-on vocational experience. The panel on this page provides a quick introduction to the terminology used in describing different types of school in England and to their respective features.

Schools in England

In England following successive layers of government reforms over the decades, there are many different types of centre that deliver school education. This panel briefly explains the general characteristics of the more common types, the landscape is complex so there may be exceptions.

There are *independent*, private fee paying, schools. These are not obliged to follow the national curriculum or employ staff qualified in teaching and they can select by academic performance for admission. The others may be regarded as different types of state school.

State maintained schools are publicly funded via local authorities (in *voluntary aided* schools the governing body contributes approximately 10% of capital costs). All are required to follow the national curriculum and employ those with Qualified Teacher Status, they cannot select by academic performance. Accountability is immediately to the local authority for *community* and *voluntary controlled* schools and can be for *foundation* schools. Otherwise, for *foundation* schools and *voluntary aided* schools accountability is via their governing body. In *community* schools the premises is owned by the local authority who also employs the school staff. For *voluntary aided* and *voluntary controlled* schools, if the founding body is the church these are sometimes referred to as *faith schools*.

Grammar schools are required to follow the national curriculum and employ qualified teachers, they can select for admissions by academic performance. While they are funded via the local authority accountability may be via either the local authority or governing body.

There are also *academies*, these can be primary or secondary schools. They are classified as independent although they are publicly funded via central government. They are not required to follow the national curriculum or employ staff with Qualified Teacher Status. Oversight is via an academy trust. *Free schools* are *academies* which are new (rather than converted existing schools). *university technical colleges* (UTCs) and *studio schools* are both *academy* types for catering to 14-18/19 year olds only. Both have a strong vocational orientation, with the latter being smaller in size. Each UTC is backed by employers and a university. *Academies* are also described as 'convertor' (former schools that were deemed to be performing well) or 'sponsored' (former schools often deemed to be underperforming and now run by sponsors).

Additionally *further education* (FE) colleges can also offer provision (including general education) post 14. There are also *sixth form colleges* which offer provision post 16.

5.1 Royal Society: *Royal Society comments on GCSE results (web page)*, August 2016. https://royalsociety.org/news/2016/08/commenting-on-gcse-results/?gclid=CJuwhc2V-84CFQqNGwodrEQKIg **5.2** Wellcome: *2016 GCSE results: our reaction*, August 2016: https://wellcome.ac.uk/news/2016-gcse-results-our-reaction **5.3** Wellcome: *2016 A level results: our reaction*, August 2016: https://wellcome.ac.uk/news/our-reaction-2016-level-results **5.4** Royal Academy of Engineering: *The UK STEM landscape*, 2016. http://www.raeng.org.uk/publications/reports/uk-stem-education-landscape **5.5** Institution of Mechanical Engineers: *Big ideas: the future of engineering in schools*, 2016. http://www.raeng.org.uk/publications/reports/imeche-big-ideas-report **5.6** DfE: *Schools, pupils and their characteristics: January 2016*, 2016. https://www.gov.uk/government/statistics/schools-pupils-and-their-characteristics-january-2016

An initiative of interest to engineering in recent years has been the development of university technical colleges (UTCs). Of the 48 UTCs now in existence,[5.7] 26 recorded GCSE results in 2016 (13 for the first time), and 27 recorded A level results (13 for the first time). Their GCSE results were closely aligned with national performance, but stronger in mathematics, sciences and IT, although many students also took BTEC and Cambridge National qualifications.[5.8] At A level, most students took mathematics and/or physics, and the overall pass rate was 90%: although at this level the majority of UTC students took a BTEC Extended Diploma, their results were strong – well above the national averages in engineering and IT. Many of the UTCs are strongly focused on STEM career sectors. UTCs are usually smaller than traditional secondary schools and are not academically selective. Their curriculum includes one or two STEM specialisms, and they are sponsored by one or more employers and a local university, and operate a longer school day to provide time for students to delve more deeply into technical areas and to complete practical tasks.[5.9]

Another recent development has been studio schools, of which there are now 30 open,[5.10] many specialising in STEM subjects. These are small schools for around 300 students aged 14-19 years. They open year-round and are based on a 9-5 working day, like a workplace. Studio schools work closely with local employers and aim to offer paid work placements linked directly to employment opportunities in the local area. However, no robust collation of their results is currently available, as many that have opened have yet to teach a year group due to taking public examinations.

Although the proportion of pupils taught in UTCs and studio schools is increasing – up by 0.67% in January 2015[5.11] – they still only accounted for just under 1% of the total cohort in January 2016.[5.12] Girls accounted for only 24% of UTC pupils and 43% of studio school pupils in 2016. Although the number of girls in UTCs is up 21% on 2015, there is still much greater interest in this form of vocationally-oriented education among boys.

Ofsted's Chief Inspector has praised the work being done by UTCs for their role in developing the scientists, engineers and technicians of the future, and raising the status and quality of technical education.[5.13, 5.14] So it is disappointing that a small number of UTCs and rather more studio schools closed in 2016, citing low pupil numbers and, in some cases, critical Ofsted reports.[5.15] Pupils start these schools at age 14. Although many in the education sector believe this is an ideal age for transition, it is currently not widely embedded as a transition age in mainstream, maintained schooling. New school types that teach from age 14 are therefore not readily understood as an option by many parents.

Any new maintained secondary school in England is designated as a free school. In summer 2016, the emphasis in the free schools programme shifted from supplying additional school places, where there is a shortfall, to providing greater choice and diversity.[5.16] This change could boost numbers of these specialist schools in the future, although the UTC programme itself is currently on pause.[5.17]

A high profile policy development is the government's announcement in September 2016 that it is consulting on the reintroduction of selective schools (including grammar schools), possibly supported by universities providing teaching capacity for A level STEM subjects.[5.18] This has prompted very active response and debate. Some commentators in the education sector have asserted that the reintroduction of selection will not, as is hoped, increase social mobility, and that it would be a retrograde policy step.[5.19] These include the Organisation for Economic Co-operation and Development (OECD), which has cautioned that international evidence does not suggest that pupil selection is directly linked to improved overall education performance.[5.20]

5.7 Baker Dearing Educational Trust: *About UTCs* (web page), 2016. http://www.utcolleges.org/about/overview/ **5.8** Baker Dearing Educational Trust: *Post-16 exam highlights 2016*, 2016. http://www.utcolleges.org/post-16-exam-highlights-2016/ **5.9** Baker Dearing Educational Trust: *About UTCs* (web page), 2016. http://www.utcolleges.org/about/overview/ **5.10** Studio Schools Trust: *What is a studio school* (web page), 2016. http://studioschoolstrust.org/node/3 **5.11** DfE: *School pupils and their characteristics*, January 2015, 2015. https://www.gov.uk/government/statistics/schools-pupils-and-their-characteristics-january-2015 **5.12** DfE: *School pupils and their characteristics*, January 2016, 2016. https://www.gov.uk/government/statistics/schools-pupils-and-their-characteristics-january-2016 **5.13** Ofsted: *Annual Report 2014/15*, 2015. https://www.gov.uk/government/collections/ofsted-annual-report-201415 **5.14** Ofsted: *Sir Michael Wilshaw's speech at the Baker Dearing UTC conference* (speech), July 2016. https://www.gov.uk/government/speeches/sir-michael-wilshaws-speech-at-the-baker-dearing-utc-conference **5.15** House of Commons Library: *University Technical Colleges*, (Briefing Paper Number 07250), 2016. http://researchbriefings.parliament.uk/ResearchBriefing/Summary/CBP-7250 **5.16** DfE: *Free schools applications: criteria for assessment, mainstream, studio and 16-19 schools*, 2016. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/541996/Free_schools_applications_criteria_for_assessment_for_mainstream_studio_and_16_to_19.pdf **5.17** House of Commons Library: *University Technical Colleges*, (Briefing Paper Number 07250), 2016. http://researchbriefings.parliament.uk/ResearchBriefing/Summary/CBP-7250 **5.18** DfE: *Schools that work for everyone*, 2016: https://consult.education.gov.uk/school-frameworks/schools-that-work-for-everyone/supporting_documents/SCHOOLS%20THAT%20WORK%20FOR%20EVERYONE%20%20FINAL.pdf **5.19** Ofsted: *Sir Michael Wilshaw's speech at the London Councils education summit* (speech), September 2016. https://www.gov.uk/government/speeches/sir-michael-wilshaws-speech-at-the-london-councils-education-summit
5.20 Sean Coughlan: *Grammar schools benefit rich, says OECD* (BBC News website), September 2016: http://www.bbc.co.uk/news/education-37364697

The Department for Education's white paper in March 2016 included relatively few references to STEM,[5.21] with the exception of announcing 44 school-led science learning partnerships, providing targeted professional development and support to improve the quality of science teaching in schools. It also stated ambitions to address the gender gap in STEM subjects and increase the proportion of entries by girls in science and mathematics by 20% during this Parliament.

Wales is grappling with many similar issues to England, but without some of the complications of structural changes to schools and qualifications/examinations. The Welsh government has recently reiterated its belief that all young people should leave school with stronger scientific literacy, so its new science GCSEs will have added focus on this.[5.22] It also believes that better STEM education would help create "a better Wales".[5.23]

The Scottish government published its *Education Delivery Plan* in June 2016,[5.24] building on its *Curriculum for Excellence* and aiming to close the attainment gap and devolve decision-making. It mentions plans to "take action to help young people develop the skills and knowledge they will need in the workplace, in particular in the areas of STEM, digital skills and languages" and also an initiative to train 20 individuals from the oil and gas sector as teachers in STEM subjects.

5.1.2 Qualification developments

Reforms to GCSE qualifications are on-going, with the first reformed GCSEs in mathematics and science set to be awarded in 2017 and 2018 respectively. It is not yet clear what the impact of these reforms will be on entry patterns and results in these subjects.

Two recent developments are Ofqual's final decision on how the new GCSE grade standards 1-9 will be assessed, along with the introduction of National Reference Tests in mathematics and English,[5.25] which will provide additional information to support the future awarding of GCSEs. Using these two measures will ensure that the proportion of entrants achieving new grades 7, 8 and 9 will be approximately equal to the proportion who achieved the old grades A* and A. It is possible, however, that the number of students awarded grade 9 could be significantly fewer than that awarded A*; Ofqual suggests the proportion could fall by half, and this could impact on progression to level 3 qualifications and beyond.[5.26]

The impact of 'compulsory' mathematics and English for post-16 students who have not achieved a grade C in GCSE is also yet to become clear. (Students will need to retake GCSE, so it is possible that the impact of a higher proportion of retakes will lead to more students just achieving a pass grade.)

The issue of compulsory mathematics post-16 is not new and many national systems have adopted it. While in England, Wales and Northern Ireland, fewer than one in five students study any mathematics after the age of 16, over half do in 18 of the 24 countries studied by the Nuffield Foundation, and in eight countries, every student studies mathematics.[5.27] Professor Sir Adrian Smith is currently undertaking a study into the feasibility of compulsory mathematics for all pupils up to 18.[5.28]

Major reforms to A and AS levels are underway: assessment will be 'linear', ie mainly by examination at the end of the course with other types of assessment used only where they are needed to test essential skills. AS assessments will typically take place after one year's study, but AS and A levels will be decoupled. This means AS results will no longer count towards an A level, in the way that they have done in England. Awarding bodies have designed specifications for standalone AS levels that can be taught alongside the first year of A levels.[5.29] Some commentators have expressed concern that the linear approach to A level assessment in subjects such as maths may deter girls, in particular, from taking up the subject, as a higher proportion are less confident in their potential ultimate outcomes than of boys, and that this could damage efforts to improve the gender balance in engineering.[5.30]

Attainment 8 is a new performance measure, based on a pupil taking a specific group of eight GCSE or GCSE-equivalent qualifications, which include STEM subjects.[5.31] It will be introduced using summer 2016 GCSE results, although some schools adopted it early in 2015. Meanwhile, Progress 8 is an additional measure which attempts to quantify individual pupils' progress from the end of primary to the end of secondary school, comparing Key Stage 2 results and GCSE results. This is perceived as a fairer measure of progress and attainment by many, but there remain unanswered questions about its potential impact, and whether it could disadvantage already weaker schools.[5.32] Another change to school performance measures that could have a significant impact is the limit imposed by the Department for Education (DfE) on the range of vocational qualifications that can be included in school performance measurements.

5.21 DfE: *Educational excellence everywhere*, 2016. https://www.gov.uk/government/publications/educational-excellence-everywhere **5.22** Welsh government: *Science, technology, engineering and mathematics (STEM) in education and training – a delivery plan for Wales*, 2016. http://gov.wales/topics/educationandskills/allsectorpolicies/stem-delivery-plan/?lang=en **5.23** Welsh government, *Qualified for life: an education improvement plan for 3- to 19-year-olds in Wales*, 2016. http://gov.wales/topics/educationandskills/allsectorpolicies/qualified-for-life-an-educational-improvement-plan/?lang=en **5.24** Scottish government: *Delivering excellence and equity in Scottish education – a delivery plan for Scotland,* 2016. http://www.gov.scot/Resource/0050/00502222.pdf **5.25** Ofqual: *An overview of the new National Reference Test*, 2016. https://www.gov.uk/government/publications/an-overview-of-the-national-reference-test **5.26** Ofqual: *Decisions on setting the grade standards of new GCSEs in England – part 2*, 2016. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/551571/Decisions_-_setting_GCSE_grade_standards_-_part_2.pdf **5.27** The Nuffield Foundation: *Is the UK an outlier? An international comparison of upper secondary mathematics education*, 2010: http://www.nuffieldfoundation.org/sites/default/files/files/Is%20the%20UK%20an%20Outlier_Nuffield%20Foundation_v_FINAL.pdf **5.28** DfE: *South Asian method of teaching maths to be rolled out in schools* (press release), 2016. https://www.gov.uk/government/news/south-asian-method-of-teaching-maths-to-be-rolled-out-in-schools **5.29** DfE: *Get the facts: AS and A level reform*, 2015. https://www.gov.uk/government/publications/get-the-facts-gcse-and-A level-reform/get-the-facts-as-and-A level-reform **5.30** THE: *Fewer women will study engineering owing to school exam changes*, November 2016. https://www.timeshighereducation.com/news/fewer-women-will-study-engineering-owing-school-exam-changes **5.31** DfE: *Progress 8 measure in 2016, 2017, and 2018 – Guide for maintained secondary schools, academies and free schools*, 2016. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/552531/Progress_8_school_performance_measure_September_16.pdf **5.32** Richard Adams: *Progress 8 and GCSEs: will the new way to judge schools be fairer?* (The Guardian website), 2016: https://www.theguardian.com/education/2016/aug/23/progress-8-gcse-results-pupils-results-schools

The English Baccalaureate (EBacc) is a performance measure intended to encourage breadth of study at Key Stage 4. It requires achievement in GCSEs across five distinct subject areas, or pillars: English, mathematics, science, a language, and either history or geography. Achievement at grade C or above in all pillars is needed to achieve the measure.[5.33] Figures for 2015 showed that 39% of the English cohort entered GCSEs in all five pillars, of whom 11% did not achieve a pass (grade C or above) in a science GCSE. Around one in ten of the 27% of the cohort who entered four pillars were in a similar position, and would similarly have a barrier to progress in STEM beyond age 16.

The EBacc has been criticised for its narrow academic focus: but mostly for a perceived lack of arts and creativity, not for a lack of STEM/vocational opportunities. Research from the Sutton Trust indicates that the EBacc has benefitted pupils – particularly those from disadvantaged backgrounds – and therefore could be said to promote social mobility. However, there are issues associated with its lack of access to the full range of subjects, especially languages and humanities. The Trust also points out that the EBacc does not suit all pupils equally well.[5.34]

Grades for GCSEs in Wales are not being altered, and will remain alphabetical, at A*-G.[5.35] Welsh AS and A levels remain linked, unlike in England, but the contribution of the AS grade to the overall A level grade has been reduced from 50% to 40%. The Welsh Baccalaureate has been modified since September 2015 at both levels 2 and 3. However, although it includes numeracy and skills for employability, it does not include any specific scientific or technological elements.[5.36]

In Scotland, 2015/16 was the third year of delivery of new Scottish National Qualifications at levels 4 and 5, and Higher level, and the first year for the Advanced Higher level.

GCSE performance in Northern Ireland in 2016 remained the highest in the UK, including strong achievement in the separate sciences and increased entries for biology, chemistry and computing (but slight reductions in physics and ICT). STEM entries accounted for almost one third of its GCSE entries.[5.37] Revised GCSEs are being developed for first teaching from September 2017; science specifications are due to be accredited in January 2017.[5.38] New GCSEs awarded will be graded A*-G, but GCSEs awarded by two English boards, AQA and OCR, will be graded 9-1.[5.39] Revised A levels have been taught in Northern Ireland schools since September 2016 (except for mathematics, which is due to be taught from September 2017). As in Wales, the link between AS and A levels has been retained.[5.40]

5.1.3 Teacher shortages

The longstanding shortage of STEM teachers continues: 28% of head teachers in relatively affluent areas report that mathematics and science are covered by temporary teaching arrangements, rising to 61% in some challenging areas.[5.41] Vacancies for teachers of STEM subjects appear to be particularly hard to fill. To meet its 2014/15 target for mathematics and physics trainees, the DfE needed to attract one in five of all mathematics and physics graduates into teaching, compared with one in 25 history graduates. In addition, leaving rates for existing mathematics and science teachers are above average, with the highest vacancy rates in 2014 being in computer science (1.5%), mathematics (1.4%), and science (1.4%), compared with an overall average rate of 0.3%.

In terms of the proportion of teacher training places filled in 2015/16, the subject with the lowest proportion was design and technology (41%). The situation was slightly better in computing (70%) and physics (71%), and better still in biology (89%), mathematics (93%) and chemistry (95%) – although these figures all still indicate shortfalls. As part of its strategy to tackle these shortfalls, the DfE is increasing bursary levels for mathematics, chemistry and biology in 2016/17, up to a ceiling of £25,000, although it has reduced the level for design and technology.[5.42] It has also introduced an experimental payment of £30,000 for physics trainees with a first class degree.

The Public Accounts Committee warned in June 2016 that the DfE had missed its targets to fill teacher training places for four years running. However, it acknowledged that teaching is competing against other attractive career options to recruit from a limited pool of graduates, especially in physics and mathematics.[5.43]

A survey by the Association of College and School Leaders found that 90% of schools are struggling to recruit enough suitably qualified teachers, especially in mathematics and sciences. Three quarters of schools are covering classes with some non-specialist staff. Finding or retaining heads of department is even more challenging.[5.44]

5.33 DfE: *Statistical release: ebacc and non-ebacc subject entries and achievement: 2010/11 to 2014/15*, 2015. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/473178/ebacc_and_non-ebacc_subject_entries_and_achievement.pdf **5.34** Sutton Trust: *Changing the subject – How are the ebacc and Attainment 8 reforms changing results?*, 2016. http://educationdatalab.org.uk/wp-content/uploads/2016/07/Changing-the-subject_FINAL.pdf **5.35** Qualifications Wales: *GCSEs*, 2016. http://qualificationswales.org/qualifications/gcses/?lang=en **5.36** Qualifications Wales: *The Welsh Baccalaureate*, 2016. http://qualificationswales.org/qualifications/welsh-baccalaureate/?lang=en **5.37** JCQ CIC: *Northern Ireland GCSE Results 2016*. http://ccea.org.uk/sites/default/files/docs/news/2016/Aug/NI%20GCSE%20news%20release%202016%20-%20final.pdf **5.38** CCEA: *The revision: revising GCSEs and A Levels* (webpage), 2016: http://ccea.org.uk/therevision/ **5.39** BBC News: GCSE: *Education Minister Peter Weir allows numbered grades* (web page), 2016: http://www.bbc.co.uk/news/uk-northern-ireland-36651791 **5.40** Agenda NI Magazine: *Meeting the challenge of revising GCSEs and A levels* (website), 2014. http://www.agendani.com/meeting-the-challenge-of-revising-gcses-and-A levels/ **5.41** Ofsted: *The Annual Report of Her Majesty's Chief Inspector of Education, Children's Services and Skills 2014/15*, 2015. https://www.gov.uk/government/publications/ofsted-annual-report-201415-education-and-skills **5.42** NAO: *Training New Teachers*, 2016. https://www.nao.org.uk/report/training-new-teachers/ **5.43** Public Accounts Committee: *Training new teachers*, 2016. http://www.publications.parliament.uk/pa/cm201617/cmselect/cmpubacc/73/73.pdf **5.44** Association of College and School Leaders: *Survey shows damage of teacher shortages* (web page), 2016. http://www.ascl.org.uk/news-and-views/news_news-detail.survey-shows-damage-of-teacher-shortages.html

Back to Contents

5.2 GCSE entries and achievements

Entries to the International GCSE (IGCSE) have declined significantly in recent years, following the decision not to include this examination in performance tables in 2017 and the introduction of a reformed GCSE in mathematics. Therefore, the focus in this section is on GCSE subjects and examinations, which apply to England, Wales and Northern Ireland. Data for Scottish qualifications at this level follow in another section.

5.2.1 GCSE entry trends

Table 5.1 summarises the number of entries for GCSE examinations in different STEM subjects in the UK (ie England, Wales and Scotland), and how these have changed over the last five years. Trends over time have to be interpreted cautiously: large changes tend to reflect the introduction and progressive take-up by schools of particular subject programmes, which may outweigh the effect of individual student choices and changing total student populations at the relevant age.

The number of entrants to the separate single-subject sciences of chemistry, biology and physics all grew in 2016 after recent falls. Along with science as a combined subject. The number of entrants to additional science grew particularly strongly. Entries to design & technology continue to decline. In computing-related subjects, entries are declining sharply in ICT, but rising fast in the recently introduced subject of computing. The number entered for engineering continues to rise steadily but makes up a comparatively small proportion of entries.

Within Table 5.2, the entrant numbers for 2015 and 2016 are detailed by gender, showing that 50.8% of all entries to GSCE subjects were by girls. At subject level, this broad proportion was maintained for mathematics, a compulsory subject, but varied quite considerably for some other subjects. There was close to parity for the separate science subjects, single science and also additional science. However, boys outnumbered girls in declining cohorts entering design & technology and ICT. They also outnumbered girls more acutely in the rising subject of computing (20.8%) and minor subject of engineering (12.2%), although the proportion of girls entering these two subjects has risen significantly between 2015 and 2016.

Table 5.1: GCSE full courses entries for selected STEM subjects (2011-2016) – all UK candidates

	2011	2012	2013	2014	2015	2016	Change over 1 year	Change over 5 years
Biology	147,904	166,168	174,428	141,900	139,199	144,148	3.6%	-2.5%
Chemistry	141,724	159,126	166,091	138,238	133,618	141,245	5.7%	-0.3%
Physics	140,183	157,377	160,735	137,227	133,610	139,805	4.6%	-0.3%
Science	405,977	552,504	451,433	374,961	395,484	408,569	3.3%	0.6%
Additional science	306,312	289,950	283,391	323,944	332,960	368,033	10.5%	20.1%
Additional science (further)	-	-	-	21,119	23,389	18,664	-20.2%	-
Computing	-	-	4,253	16,773	35,414	62,454	76.4%	-
Design and technology	253,624	240,704	219,931	213,629	204,788	185,279	-9.5%	-26.9%
Engineering	1,850	2,128	2,897	5,027	6,909	7,714	11.7%	317.0%
ICT	47,128	53,197	69,234	96,811	111,934	84,120	-24.8%	78.5%
Mathematics	772,944	675,789	760,170	736,403	761,230	757,296	-0.5%	-2.0%
All subjects	5,151,970	5,225,288	5,445,324	5,217,573	5,277,604	5,240,796	-0.7%	1.7%

Source: JCQ

5.2.2 GCSE achievement rates

Arguably, the number of examinations passed is as – or more – important than the number of entrants, as achievement is generally required for progression to higher level study. Table 5.2 shows the numbers of entrants for GCSE examinations for STEM subjects, the A*-C pass rate and the number achieving those grades.[5.45]

Trends in pass rates over time should be treated with caution as efforts are made to moderate overall examination grading. However, the pass rate at A*-C fell significantly in 2016 (by around two percentage points) which has caused numerous press headlines. Some have attributed this to recent changes in the education system, including the rise in the compulsory participation age to 18 and the requirement to achieve at least a grade C in English and mathematics, which has resulted in a greater number of examinations being retaken by 17-year-olds. However, this does not appear to account for the overall apparent decline in performance on this measure.

At subject level, the overall pass rate at A*-C declined by around 4% for science and additional science and by 1% for single science subjects, against an all-subject decline of 2%. The A*-C pass rates for separate science subjects were much higher (at just over 90%) than for science (53%), mathematics or additional science (both around 60%). This presumably reflects that different segments of the cohort (potentially in different types of school) selected these subjects.

Table 5.2 also shows that girls are out-performing boys: they are obtaining 54% of all A*-C grades, despite comprising just under 51% of entrants. In terms of the overall pass rate at A*-C, girls out-performed boys by nine percentage points (71% compared with 62%), which was a fractionally larger difference than seen in 2015. For every subject except mathematics (where there was close to parity), the A*-C pass rate for girls was higher than for boys. However, the extent of this difference was lower in science subjects, and much lower for separate science subjects, than it was across all subjects. In all subjects except mathematics, the proportion of A*-C grades achieved by girls was higher than the proportion of female entrants.

5.45 Grades A*-G are considered passes in GCSEs. However, we deliberately concentrate on passes at A*-C grade as these tend to be the requirement to pursue subjects post-16 including to A level.

Back to Contents

The proportion of school pupils in England with minority ethnic origins has been rising steadily since 2006. In primary schools in 2016, 31% of pupils are of minority ethnic origin – up 1% on 2015. Pupils with these backgrounds made up two thirds of the increase in pupil numbers in primary schools between 2015 and 2016.[5.46] White non-British pupils now make up 7% of the population in primary schools and were the second largest ethnic minority at this level, after pupils from Asian backgrounds.

In secondary schools, almost 28% of pupils in England were of minority ethnic origins in 2016 – well above 2015's 26.6%. Pupils from Asian and black origins were the two largest minorities in secondary schools. In terms of achievement, DfE analysis suggests that Chinese origin pupils were the highest achieving ethnic group at GCSE, with 74% achieving at least five GCSEs at grades A*-C including English and mathematics. This is well above the national average of 56.6%.[5.47] Pupils from a black background were the lowest achieving of the major ethnic groups, with just over half (53.1%) achieving at least five A*-C GCSEs (or equivalent) including English and mathematics. However, three quarters of black pupils were making the expected progress in English and over two thirds were progressing as expected in mathematics, which is above national average.

There is current policy concern that the achievement of pupils from a white British background has fallen below the national average, and that the relative achievement of white British working class boys is particularly low.

Table 5.2: Number of GCSE A*-C passes achieved (2015 and 2016) – all UK candidates

		2015			2016		
		Entrants	Percentage achieving % A*-C	Calculated number of pupils achieving A*-C	Entrants	Percentage achieving % A*-C	Calculated number of pupils achieving A*-C
Biology	Total	139,199	90.9%	126,532	144,148	90.5%	130,454
	Male	69,657	90.0%	62,691	71,576	89.7%	64,204
	Female	69,542	91.8%	63,840	72,572	91.3%	66,258
	% Female	50.0%	-	50.5%	50.3%	-	50.8%
Chemistry	Total	133,618	91.2%	121,860	141,245	90.3%	127,544
	Male	68,391	90.1%	61,620	71,119	88.9%	63,225
	Female	65,227	92.4%	60,270	70,126	91.7%	64,306
	% Female	48.8%	-	49.5%	49.6%	-	50.4%
Physics	Total	133,610	92.0%	122,921	139,805	90.9%	127,083
	Male	68,389	91.8%	62,781	71,006	90.8%	64,473
	Female	65,221	92.2%	60,134	68,799	91.0%	62,607
	% Female	48.8%	-	48.9%	49.2%	-	49.3%
Science	Total	395,484	56.7%	224,239	408,569	52.9%	216,133
	Male	197,125	60.0%	118,275	205,589	49.8%	102,383
	Female	198,359	53.4%	105,924	202,980	56.0%	113,669
	% Female	50.2%	-	47.2%	49.7%	-	52.6%
Additional science	Total	332,960	63.2%	210,431	368,033	59.7%	219,716
	Male	162,588	60.3%	98,041	182,035	56.6%	103,032
	Female	170,372	66.0%	112,446	185,998	62.7%	116,621
	% Female	51.2%	-	53.4%	50.5%	-	53.1%
Additional science (further)	Total	23,389	79.8%	18,664	17,409	76.9%	13,388
	Male	11,686	77.7%	9,080	8,793	75.0%	6,595
	Female	11,703	81.8%	9,573	8,616	78.9%	6,798
	% Female	50.0%	-	51.3%	49.5%	-	50.8%
Computing	Total	35,414	65.1%	23,055	62,454	60.4%	37,722
	Male	29,736	63.9%	19,001	49,926	59.8%	29,856
	Female	5,678	71.7%	4,071	12,528	62.7%	7,855
	% Female	16.0%	-	17.7%	20.1%	-	20.8%
Design and technology	Total	204,788	60.8%	124,511	204,788	60.9%	124,716
	Male	123,571	53.5%	66,110	112,702	53.1%	59,845
	Female	81,217	71.9%	58,395	72,577	73.0%	52,981
	% Female	39.7%	-	46.9%	35.4%	-	42.5%
Engineering	Total	6,909	40.3%	2,784	7,714	40.7%	3,140
	Male	6,398	38.9%	2,489	7,080	38.9%	2,754
	Female	511	57.7%	295	634	60.4%	383
	% Female	7.4%	-	10.6%	8.2%	-	12.2%
ICT	Total	111,934	68.8%	77,011	84,120	67.9%	57,117
	Male	64,777	66.4%	43,012	49,993	64.3%	32,145
	Female	47,157	72.1%	34,000	34,127	73.1%	24,947
	% Female	42.1%	-	44.2%	40.6%	-	43.7%
Mathematics	Total	761,230	63.3%	481,859	757,296	61.0%	461,951
	Male	373,603	63.9%	238,732	370,914	61.3%	227,370
	Female	387,627	62.6%	242,655	386,382	60.8%	234,920
	% Female	50.9%	-	50.4%	51.0%	-	50.9%
All subjects	Total	5,277,604	69.0%	3,641,547	5,240,796	66.9%	3,506,093
	Male	2,588,865	64.7%	1,674,996	2,579,722	62.4%	1,609,747
	Female	2,688,739	73.1%	1,965,468	2,661,074	71.3%	1,897,346
	% Female	50.9%	-	54.0%	50.8%	-	54.1%

Source: JCQ

5.46 DfE: *Schools, pupils and their characteristics: January 2016*, 2016. https://www.gov.uk/government/statistics/schools-pupils-and-their-characteristics-january-2016

5.47 DfE: *Statistical First Release: GCSE and equivalent attainment by pupil characteristics*, 2013 to 2014 (Revised), January 2015. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/399005/SFR06_2015_Text.pdf

The A*-C pass rates achieved for GCSEs are shown over a longer period in Table 5.3. This shows a consistently higher proportion of students achieving A*-C passes in separate science subjects than in science or additional science, computing or mathematics. The significant variations in pass rate over time reflect changes to some curricula and reforms such as the shift from modular to linear assessment: this may have affected schools' decisions on which subjects they enter pupils for. The adjustment in school performance tables so that only first attempts to sit an examination are counted may also impact on this to some extent.

Table 5.4 shows the A*-C achievement rate by English region and devolved nation for the past three years. Within England, London and the South East continue to achieve the highest rates of GCSE passes at grades A*-C, at around 70% (although these have fallen by just under two percentage points in the last year). Comparison with much older data shows the marked improvement in attainment that has been achieved by London's maintained schools and their pupils since the turn of the century, sometimes known as the 'London effect'. For example, in 2002 London had a lower than average pass rate (56.8% of pupils achieving A*-C, below the UK average of 57.9%). It is believed that London's schools have disproportionately benefited from improvements to the education system as a whole, while similar pupils and schools elsewhere in England have also improved but by a lesser extent.[5.48]

In contrast, pupils in Yorkshire and the Humber and the East Midlands obtained the lowest proportion of passes at A*-C (under 64%).

The performance, on this measure, of pupils in Northern Ireland was the strongest in the UK, with 79% obtaining A*-C passes, and this was the only region or nation where this figure has increased over the past two years. The proportion in Wales has remained static at just under 67%.

Table 5.3: GCSE A*-C pass rates (2011-2016) – all UK candidates

	2011	2012	2013	2014	2015	2016	Change over 1 year (%p)	Change over 5 years (%p)
Biology	93.1%	92.6%	89.8%	90.3%	90.9%	90.5%	-0.4	-2.6
Chemistry	93.1%	93.0%	90.0%	90.7%	91.2%	90.3%	-0.9	-2.8
Physics	93.7%	93.2%	90.8%	91.3%	92.0%	90.9%	-1.1	-2.8
Science	62.9%	60.7%	53.1%	59.1%	56.7%	52.9%	-3.8	-10.0
Additional science	66.2%	66.4%	64.1%	65.5%	63.2%	59.7%	-3.5	-6.5
Additional science (further)	-	-	-	84.2%	79.8%	76.9%	-2.9	76.9
Computing	-	-	68.4%	65.5%	65.1%	60.4%	-4.7	60.4
Design and technology	62.4%	62.7%	61.8%	61.0%	60.8%	60.9%	0.1	-1.5
Engineering	46.5%	46.8%	41.1%	41.6%	40.3%	40.7%	0.4	-5.8
ICT	77.2%	74.7%	72.2%	69.5%	68.8%	67.9%	-0.9	-9.3
Mathematics	58.8%	58.4%	57.6%	62.4%	63.3%	61.0%	-2.3	2.2
Statistics	78.6%	80.0%	77.4%	70.2%	71.3%	70.2%	-1.1	-8.4
All subjects	69.8%	69.4%	68.1%	68.8%	69.0%	66.9%	-2.1	-2.9

Other sciences includes all sciences except: Addditional Science, Biology, Chemistry, Physics and Science
Source: JCQ

Table 5.4: Proportion of GCSE entries achieving an A*-C grade, by English region and devolved nation (2014-2016) – all UK candidates

	2014	2015	2016	Change over 1 year (%p)	Change over 2 years (%p)
North East	65.7%	67.2%	65.0%	-2.2	-0.7
North West	68.3%	68.6%	65.5%	-3.1	-2.8
Yorkshire and The Humber	64.9%	65.3%	63.5%	-1.8	-1.6
West Midlands	66.7%	66.9%	64.0%	-2.9	-2.7
East Midlands	65.7%	65.6%	63.6%	-2.0	-2.1
Eastern	68.8%	69.0%	66.5%	-3.5	-2.3
South West	69.0%	69.1%	66.9%	-2.2	-2.1
South East	70.9%	70.9%	69.4%	-1.5	-1.5
London	71.7%	72.0%	70.1%	-1.9	-1.6
Wales	66.6%	66.6%	66.6%	0.0	0.0
Northern Ireland	78.0%	78.7%	79.1%	0.4	1.1
All UK	68.8%	69.0%	66.9%	-2.1	-1.9

Source: JCQ

5.48 Centre for Market and Public Organisation: *Understanding the success of London's schools*, October 2014. http://www.bristol.ac.uk/media-library/sites/cmpo/migrated/documents/wp333.pdf

5.3 Vocational qualifications

For many pupils, vocational qualifications offer a viable alternative pathway to higher level study. Although Ofsted has previously suggested that the number of pupils studying vocational science courses at level 2 will decrease in response to the EBacc measure,[5.49] other new initiatives such as the introduction of 'technical awards' are likely to ensure that vocational qualifications continue to form a significant part of the 14-16 education landscape. Technical awards are vocational qualifications, closely related to the world of work, that are designed to provide pupils with a first step on a path to higher level vocational study, whilst still attaining a firm academic grounding in core subjects at level 2. Pupils aged 14 to 16 years are being encouraged to study up to three technical awards alongside five core GCSEs, and this combination will be counted within the performance indicators for their school.[5.50]

The list of prescribed technical awards includes a number of BTEC and OCR qualifications, as well as others from other providers. As shown in Chapter 7, in relation to the qualifications held by young people entering higher education, it is becoming common for students to obtain both vocational and academic qualifications, such as a combination of BTEC awards and GCSEs at age 16. Pearson reports that nearly 330,000 students under the age of 19 achieved BTEC qualifications in 2015/16, although this was below the peak of well over 500,000 in 2012/13.[5.51] These included over 15,000 BTECs in engineering and 22,000 in ICT/computing. Similarly, around 60,000 OCR Cambridge national awards at level 2 were obtained in 2016, of which more than half were in IT, and in 2017 the first teaching will take place of OCR's new Cambridge Technicals at level 2, which will include engineering and IT.[5.52]

What is clear is that the number of achievements of specific vocational qualifications at level 2 are currently relatively volatile in the face of changing policy and practice, both for this educational stage and more generally (see also Chapter 7).

5.4 Scottish qualifications

New 'National 5' qualifications have replaced the former 'Intermediate 2' suite of qualifications in Scotland, with 2015 the last examination year in which it was possible to take the latter. Table 5.5 summarises the entrants and pass rates achieved in STEM subjects at National 5 level, showing that there were 295,000 entries. This was, overall, slightly higher than the total in 2015, when there were also around 10,000 residual Intermediate 2 entries.

Compared with an overall pass rate (at grades A-C) of just under 80%, the pass rates in biology, chemistry and physics were all at around 75%, while in mathematics the pass rate at these grades was lower at 63%. This pattern is somewhat different to that for UK GCSEs, where the pass rate for mathematics is roughly similar to the all-subject average, much higher for separate sciences and somewhat lower for science or additional science. However, it is likely that there will be some shift in the pattern of Scottish results as the new qualifications bed in fully.

Students are also eligible to undertake lower-level National 4 qualifications, which roughly correspond to a GCSE at grades D-G. However, these are not subject to external examination or assessment, and it is possible that they will not afford much recognition by educational institutions or employers.[5.53]

5.49 Ofsted: *Maintaining curiosity – A survey into science education in schools*, November 2013, p25. https://www.gov.uk/government/publications/maintaining-curiosity-a-survey-into-science-education-in-schools **5.50** DfE: *Qualifications for 14-16 Year Olds: 2017 and 2018 performance tables: technical guidance for awarding organisations*, August 2016. **5.51** Data provided by Pearson plc, provided September 2016 **5.52** OCR: *Cambridge Technicals 2016 suite*, (web page), 2016 http://www.ocr.org.uk/qualifications/by-type/cambridge-technicals/cambridge-technicals-2016/ **5.53** Simon Johnson: *Scottish parents and pupils 'do not attach much value' to new National qualifications*, Telegraph, February 2014. http://www.telegraph.co.uk/news/politics/10654856/Scottish-parents-and-pupils-do-not-attach-much-value-to-new-National-qualifications.html

Table 5.5: Attainment in selected STEM National 5 qualifications (2015-2016) – Scotland[5.54, 5.55]

		2015	2016	Change over 1 year
Administration and IT	Entries	5,619	5,448	-3.0%
	Percentage A-C	78.4%	78.8%	0.4
	Number A-C	4,404	4,295	-2.5%
Biology	Entries	21,635	21,211	-2.0%
	Percentage A-C	70.7%	73.3%	2.6
	Number A-C	15,298	15,548	1.6%
Chemistry	Entries	16,659	17,046	2.3%
	Percentage A-C	72.5%	76.1%	3.6
	Number A-C	12,074	12,971	7.4%
Computing science	Entries	7,663	7,927	3.4%
	Percentage A-C	83.5%	82.4%	-1.1%
	Number A-C	6,399	6,533	2.1%
Design and manufacture	Entries	5,169	4,903	-5.1%
	Percentage A-C	85.6%	83.6%	-2
	Number A-C	4,427	4,099	-7.4%
Engineering science	Entries	1,808	1,831	1.3%
	Percentage A-C	86.0%	80.8%	-5.2
	Number A-C	1,555	1,480	-4.8%
Fashion and textile technology	Entries	475	571	20.2%
	Percentage A-C	98.3%	92.3%	-6
	Number A-C	467	527	12.8%
Health and food technology	Entries	1,963	1,904	-3.0%
	Percentage A-C	77.1%	82.5%	5.4
	Number A-C	1,513	1,570	3.8%
Lifeskills mathematics	Entries	2,739	2,796	2.1%
	Percentage A-C	30.8%	35.8%	5
	Number A-C	844	1,000	18.5%
Mathematics	Entries	36,475	41,780	14.5%
	Percentage A-C	61.8%	63.2%	1.4
	Number A-C	22,536	26,412	17.2%
Music technology	Entries	498	745	49.6%
	Percentage A-C	94.0%	88.7%	-5.3
	Number A-C	468	661	41.2%
Physics	Entries	14,942	14,888	-0.4%
	Percentage A-C	75.1%	74.0%	-1.1
	Number A-C	11,067	11,016	-0.5%
Practical electronics	Entries	125	119	-4.8%
	Percentage A-C	84.0%	76.5%	-7.5
	Number A-C	105	91	-13.3%
Practical metalworking	Entries	934	1,149	23.0%
	Percentage A-C	93.9%	94.9%	1.0%
	Number A-C	877	1,090	24.3%
Practical woodworking	Entries	4,279	4,366	2.0%
	Percentage A-C	93.7%	94.3%	0.6
	Number A-C	4,009	4,117	2.7%
All subjects	Entries	288,016	295,083	2.5%
	Percentage A-C	79.8%	79.4%	-0.4
	Number A-C	229,870	234,160	1.9%

Source: SQA

5.5 A level qualifications

5.5.1 A level entrants

In this edition of *The state of engineering* we are choosing to focus largely on A levels (in England, Wales and Northern Ireland) as well as Scottish Highers. As indicated in Section 5.1, fundamental changes are currently underway in relation to AS levels in particular, as these are being decoupled from A levels in England. As a result, new AS and A levels in some STEM subjects were introduced for teaching in September 2015, while others will follow from 2017. We will also focus mainly on achievements in these qualifications, rather than entry numbers, partly for the purposes of brevity. However, it will be interesting in future to monitor whether there is any impact on A level entry numbers following the decoupling of AS levels.

STEM A levels and equivalent qualifications are valuable as a means to progress onto higher level study and also as standalone qualifications. Research conducted by London Economics found that for those whose highest qualifications were A levels, having one STEM A level boosted earnings by approximately 15 percentage points compared with having only non-STEM A level, and by 20% compared with those who have only GCSEs.[5.56] The earnings premium appears to be relatively greater for women.

STEM A levels hold additional merit in facilitating entry to higher education and some universities in particular. In 2012, the Russell group placed A levels in biology, chemistry, physics, mathematics and further mathematics in its group of key ‘facilitating subjects’, which it believes increase the chances of pupils attending what it calls ‘elite’ universities.[5.57] However, uptake of these facilitating subjects at A level is not equal across society. Only one third of gifted but disadvantaged students entered one or more A levels in these subjects, compared with three fifths of gifted but more advantaged students.[5.58]

5.54 SQA: Attainment Statistics (August) 2016. Available at: http://www.sqa.org.uk/sqa/files_ccc/Attainment_Statistics_(August)_2016.xsl Tabulation excludes groupings with fewer than 100 A-D grades **5.55** National Course (National 5) statistics relate to information as of August and are therefore subject to change later in the year. These statistics are course-based analyses, i.e. results are dependent on both the learner's course assessment result (where applicable) and their successful completion of the related units. **5.56** London Economics: *The earnings and employment returns to A levels: A report to the Department for Education*, February 2015. http://londoneconomics.co.uk/wp-content/uploads/2015/03/London-Economics-Report-Returns-to-GCE-A levels-Final-12-02-2015.pdf **5.57** Russell Group: *Informed choices: a Russell Group guide to make decisions about post-16 education.* 2012 **5.58** University of Oxford and Sutton Trust: *Subject to background what promotes better achievement for bright but disadvantaged students?* March 2015. http://www.suttontrust.com/wp-content/uploads/2015/03/Subject-to-background1.pdf

Back to Contents

Table 5.6 shows entrant numbers to A level STEM subjects over the last five years. Against a fall in total A level entry numbers since 2011, there have been significant rises in the number of entrants to mathematics, chemistry, physics and biology, although with some small fluctuations (including decreases in the last year). Further mathematics and computing, while not so large numerically, have seen even greater percentage rises in entrants over five years, at 24% and 56% respectively (although the latter must be seen alongside the strong decline in entrants to ICT).

Some of these rises have been fuelled by rising numbers of female entrants. The proportion of female entrants in the three science subjects has risen at least slightly over the period, but fallen back slightly in mathematics. Female entrants comprised just under 10% in computing, 22% in physics, 28% in further mathematics and 39% in mathematics, but half in chemistry and nearly two thirds in biology.

In terms of overall A level subject popularity, mathematics remains the most commonly entered subject, making up 11% of all A level entries (Table 5.7). Chemistry was sixth most popular and physics ninth, but both were outnumbered significantly by biology and psychology.

Table 5.6: GCE A level STEM subject entrant numbers (2011-2016) – all UK candidates

		2011	2012	2013	2014	2015	2016	Change over 1 year	Change over 5 years
Biology	Total entries	62,041	63,074	63,939	64,070	63,275	62,650	-1.0%	1.0%
	% Female	56.6%	56.5%	57.8%	58.9%	60.6%	61.1%	0.5%p	4.5%p
Chemistry	Total entries	48,082	49,234	51,818	53,513	52,644	51,811	-1.6%	7.8%
	% Female	47.3%	47.2%	47.9%	48.4%	49.1%	49.9%	0.8%p	2.6%p
Computing	Total entries	4,002	3,809	3,758	4,171	5,383	6,242	16.0%	56.0%
	% Female	7.5%	7.8%	6.5%	7.5%	8.5%	9.8%	1.3%p	2.2%p
ICT	Total entries	11,960	11,088	10,419	9,479	9,124	8,737	-4.2%	-26.9%
	% Female	39.1%	38.6%	37.7%	36.1%	35.7%	35.8%	0.1%p	-3.3%p
Mathematics	Total entries	82,995	85,714	88,060	88,816	92,711	92,163	-0.6%	11.0%
	% Female	40.0%	40.0%	39.3%	38.7%	38.8%	38.7%	-0.1%p	-1.3%p
Further mathematics	Total entries	12,287	13,223	13,821	14,028	14,993	15,257	1.8%	24.2%
	% Female	31.2%	30.0%	28.6%	28.3%	27.9%	27.5%	-0.3%p	-3.6%p
Physics	Total entries	32,860	34,509	35,569	36,701	36,287	35,344	-2.6%	7.6%
	% Female	20.8%	21.3%	20.7%	21.1%	21.5%	21.6%	0.2%p	0.8%p
Other science subjects	Total entries	3,277	3,375	3,477	3,486	3,481	3,304	-5.1%	0.8%
	% Female	22.8%	22.6%	23.1%	22.8%	24.2%	24.7%	0.6%p	1.9%p
Design and technology/ technology subjects	Total entries	18,249	17,105	14,374	13,691	13,240	12,477	-5.8%	-31.6%
	% Female	42.2%	42.7%	41.4%	40.8%	40.5%	38.6%	-1.8%p	-3.6%p
All subjects	Total entries	867,317	861,819	850,752	833,807	850,749	836,705	-1.7%	-3.5%
	% Female	53.7%	54.1%	54.2%	54.4%	54.9%	55.2%	0.2%p	1.5%p

Source: JCQ

Table 5.7: Top 10 GCE A level subjects by number of entries in 2016

A level 2016			
Ranking	**Subject**	**Percentage of all subject entries**	**Number of entries**
1	**Mathematics**	11.0%	92,163
2	**English**	10.1%	84,710
3	**Biology**	7.5%	62,650
4	**Psychology**	7.1%	59,469
5	**History**	6.5%	54,731
6	**Chemistry**	6.2%	51,811
7	**Art and design subjects**	5.2%	43,242
8	**Geography**	4.3%	36,363
9	**Physics**	4.2%	35,344
10	**Sociology**	4.1%	33,980

Source: JCQ

5.5.2 A level achievement rates

Table 5.8 shows the number of pupils achieving A levels at grades A*-C[5.59] in 2014, 2015 and 2016, broken down by gender (the results quoted for 2016 are provisional). A number of trends are evident. Out of 835,705 entries, 77.6% (almost 650,000 students) gained A levels at grades A*-C: almost no change on 2015 (77.3%). Female students again outperformed males, with almost 80% of females attaining at this level compared with 75% of males.

By subject numbers, there was a 3% drop in the number of chemistry students gaining grades A*-C between 2015 and 2016. This is due in almost equal parts to a drop in entrants and a slightly lower rate of achievement. There was a 2.7% drop in physics achievements, due almost entirely to a lower entrant number in 2016. For the popular subjects of biology and mathematics the numbers and proportions were very stable. Further mathematics, with a much smaller and male-dominated cohort, saw a rise of 2% in the number of students attaining at this level. A*-C grades in computing rose by 20%. However, this is a small but growing subject (dominated 10:1 by males), that is likely to be benefiting from the decline in ICT (down 4% in 2016). The absolute number of students achieving top grades in design and technology rose by 7%, despite a slight fall in the proportion of students achieving these grades: this reflects recent growth in student numbers.

Looking at each subject by proportion of A*-C achievements shows a less complex picture. In fact, most disciplines moved up or down by only around one percentage point. The exception was computing, which rose by two percentage points, for the reasons previously stated.

Interestingly, most of the fall in numbers obtaining A*-C grades in physics and chemistry between 2015 and 2016 was due to lower performance of males. A higher proportion of females than males gained A*-C grades in all individual subjects apart from further maths in 2016. The most marked differences were seen

Table 5.8: Number of GCE A level passes at grades A*-C, by gender (2015-2016) – all UK candidates

		2015			2016				
		Total number of students	Percentage A*-C	Calculated number of students obtaining a grade A*-C	Total number of students	Percentage A*-C	Calculated number of students obtaining a grade A*-C	Change in number of students obtaining grades A*-C 2015-2016	Percentage change in numbers of students obtaining a grade A*-C 2015-2016
Biology	Total	63,275	71.9%	45,495	62,650	72.6%	45,484	-11	0.0%
	Male	24,955	70.5%	17,593	24,371	71.8%	17,498	-95	-0.5%
	Female	38,320	72.8%	27,897	38,279	73.1%	27,982	85	0.3%
Chemistry	Total	52,644	78.2%	41,168	51,811	77.0%	39,894	-1,273	-3.1%
	Male	26,771	78.0%	20,881	25,937	76.9%	19,946	-936	-4.5%
	Female	25,873	78.3%	20,259	25,874	77.1%	19,949	-310	-1.5%
Computing	Total	5,383	60.0%	3,230	6,242	62.1%	3,876	646	20.0%
	Male	4,927	59.8%	2,946	5,633	61.4%	3,459	512	17.4%
	Female	456	62.9%	287	609	68.5%	417	130	45.4%
ICT	Total	9,124	58.6%	5,347	8,737	58.7%	5,129	-218	-4.1%
	Male	5,870	54.6%	3,205	5,613	53.9%	3,025	-180	-5.6%
	Female	3,254	65.8%	2,141	3,124	67.3%	2,102	-39	-1.8%
Mathematics	Total	92,711	79.8%	73,983	92,163	80.2%	73,915	-69	-0.1%
	Male	56,774	79.4%	45,079	56,535	79.8%	45,115	36	0.1%
	Female	35,937	80.4%	28,893	35,628	80.8%	28,787	-106	-0.4%
Further mathematics	Total	14,993	87.7%	13,149	15,257	87.9%	13,411	262	2.0%
	Male	10,816	87.4%	9,453	11,054	88.7%	9,805	352	3.7%
	Female	4,177	88.6%	3,701	4,203	88.1%	3,703	2	0.1%
Physics	Total	36,287	71.5%	25,945	35,344	71.4%	25,236	-710	-2.7%
	Male	28,500	70.6%	20,121	27,699	70.6%	19,555	-566	-2.8%
	Female	7,787	74.9%	5,832	7,645	74.2%	5,673	-160	-2.7%
Design and technology/ technology subjects	Total	11,491	68.4%	7,860	12,477	67.5%	8,422	562	7.2%
	Male	6,707	64.4%	4,319	7,655	64.3%	4,922	603	14.0%
	Female	4,784	74.3%	3,555	4,822	72.6%	3,501	-54	-1.5%
All subjects	Total	782,325	77.3%	604,737	836,705	77.6%	649,283	44,546	7.4%
	Male	352,862	74.5%	262,882	375,226	75.0%	281,420	18,537	7.1%
	Female	429,463	79.6%	341,853	461,479	79.7%	367,799	25,946	7.6%

Source: JCQ

5.59 Although grades A* to G are considered a pass, only the A*-C achievement rate is considered as these are grades which most universities will consider when enrolling students.

in ICT (a difference of more than 13 percentage points), other science subjects (9.5 percentage points), design and technology (8.3 percentage points) and computing (7.1 percentage points). Physics and mathematics showed only a small performance difference: 3 and 1 percentage points respectively. Only in further mathematics did males outperform females using this yardstick – and then by less than one percentage point.

Table 5.9 shows the percentage of A level students that achieved a grade A*-C from 2011 to 2016. The trend overall (ie across all subjects) has been for a gradually rising proportion to attain at this level, with the 2016 proportion the highest on record.

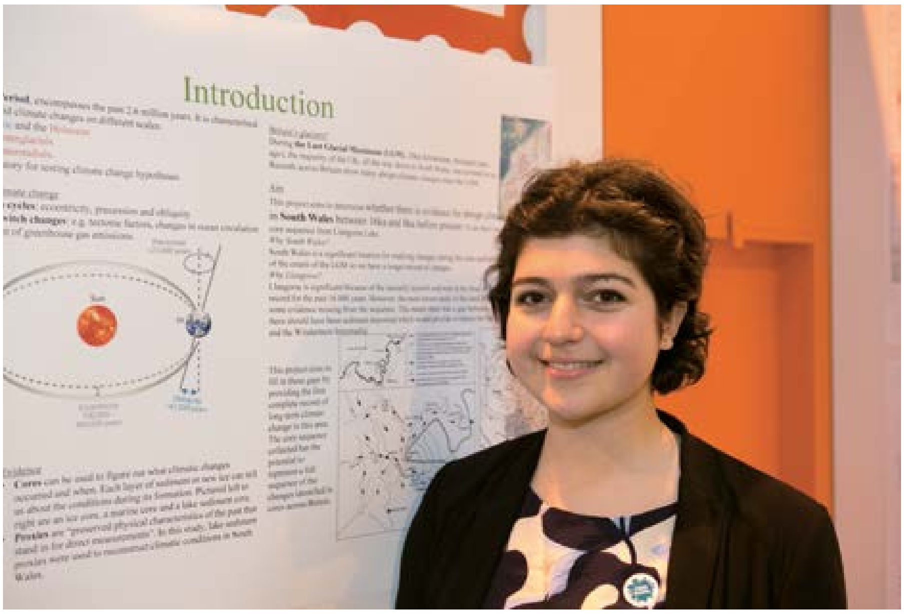
However, the achievement rates for all of the STEM subjects listed, including the key facilitating STEM A level disciplines, have tended not to rise but to decline slightly over the same period. This trend continued in the past year for chemistry and design and technology, although attainment for physics and mathematics was stable and there were small rises in computing and further mathematics.

At 71.4%, the A*-C achievement rate for physics is lower than the average across all subjects, and also lower than for other key STEM subjects, especially chemistry (77%), mathematics (80%) and further mathematics (88%). It is, however, higher than for computing or ICT. This could lead to the assumption that physics in particular is a ‘harder’ subject than many non-STEM subjects or other subjects within STEM, which could hinder participation. Research has shown that physics is a relatively difficult subject at A level, but that chemistry and further mathematics are more difficult still, yet both these subjects have higher pass rates.[5.60] This suggests that the lower A*-C achievement rate for physics is unlikely to be due to the difficulty in its content, but due either to it being a relatively lower-ability cohort, and/or weaker teaching or more stringent assessment criteria compared with some other subjects.

Table 5.9: Proportion achieving grade A*-C at GCE A level (2011-2016) – all UK candidates

	2011	2012	2013	2014	2015	2016	Change over 1 year (%p)	Change over 5 years (%p)
Biology	73.3%	73.7%	73.7%	72.0%	71.9%	72.6%	0.7	-0.7
Chemistry	78.2%	79.1%	79.5%	78.0%	78.2%	77.0%	-1.2	-1.2
Computing	62.6%	60.8%	61.1%	61.3%	60.0%	62.1%	2.1	-0.5
ICT	60.6%	62.8%	65.1%	60.6%	58.6%	58.7%	0.1	-1.9
Mathematics	81.8%	81.6%	81.3%	80.5%	79.8%	80.2%	0.4	-1.6
Further mathematics	89.5%	89.4%	89.9%	87.8%	87.7%	88.1%	0.4	-1.4
Physics	73.5%	74.0%	73.9%	72.2%	71.5%	71.4%	-0.1	-2.1
Design and technology/ technology subjects	70.2%	69.9%	70.1%	68.8%	68.4%	67.5%	-0.9	-2.7
Other science subjects	75.2%	76.4%	76.3%	76.0%	77.6%	70.2%	-7.4	-5
All Subjects	76.2%	76.6%	77.2%	76.7%	77.3%	77.6%	0.3	1.4

Source: JCQ



5.60 The Nuffield Foundation: *Mathematics after 16: the state of play, challenges and ways ahead*, 2014, p12. http://www.nuffieldfoundation.org/sites/default/files/files/Mathematics_after_16_v_FINAL.pdf

Table 5.10: Number of GCE A level A*-C passes, by nation and by gender (2014-2015) – all UK candidates

		2015			2016				
ENGLAND		**Total number of students**	**Percentage A*-C**	**Calculated number of students obtaining a grade A*-C**	**Total number of students**	**Percentage A*-C**	**Calculated number of students obtaining a grade A*-C**	**Change in number obtaining grade A*-C 2015-2016**	**Percentage change in number obtaining grade A*-C 2015-2016**
Chemistry	Total	48,467	76.8%	37,223	47,643	78.0%	37,162	-61	-0.2%
	Male	24,675	78.0%	19,247	23,881	76.8%	18,341	-906	-4.7%
	Female	23,792	78.0%	18,558	23,762	76.9%	18,273	-285	-1.5%
Computing	Total	4,925	59.8%	2,945	5,710	61.2%	3,495	549	18.7%
	Male	4,504	59.8%	2,693	5,174	61.2%	3,166	473	17.6%
	Female	421	62.7%	264	536	68.7%	368	104	39.5%
ICT	Total	6,370	56.1%	3,574	6,778	56.5%	3,830	256	7.2%
	Male	4,392	51.7%	2,271	4,216	51.6%	2,175	-95	-4.2%
	Female	2,386	64.0%	1,527	2,154	66.0%	1,422	-105	-6.9%
Mathematics	Total	85,648	79.4%	68,005	85,068	79.9%	67,969	-35	-0.1%
	Male	52,578	79.1%	41,589	52,390	79.7%	41,755	166	0.4%
	Female	33,070	80.0%	26,456	32,678	80.4%	26,273	-183	-0.7%
Further mathematics	Total	14,298	87.5%	12,511	14,566	87.9%	12,804	293	2.3%
	Male	10,316	87.2%	8,996	10,583	87.7%	9,281	286	3.2%
	Female	3,982	88.4%	3,520	3,983	88.6%	3,529	9	0.3%
Physics	Total	33,207	71.3%	23,677	32,419	71.2%	23,082	-594	-2.5%
	Male	26,133	70.4%	18,398	25,472	70.4%	17,932	-465	-2.5%
	Female	7,074	74.6%	5,277	6,947	73.8%	5,127	-150	-2.8%
Design and technology/ technology subjects	Total	11,491	68.0%	7,814	10,763	67.3%	7,243	-570	-7.3%
	Male	6,707	63.7%	4,272	6,501	63.9%	4,154	-118	-2.8%
	Female	4,784	74.2%	3,550	4,262	72.4%	3,086	-464	-13.1%
All subjects	Total	782,325	77.2%	603,955	769,340	77.5%	596,239	-7,716	-1.3%
	Male	352,862	74.4%	262,529	345,632	75.0%	259,224	-3,305	-1.3%
	Female	429,463	79.5%	341,423	423,708	79.6%	337,272	-4,152	-1.2%
		2015			**2016**				
WALES		**Total number of students**	**Percentage A*-C**	**Calculated number of students obtaining a grade A*-C**	**Total number of students**	**Percentage A*-C**	**Calculated number of students obtaining a grade A*-C**	**Change in number of students obtaining grades A*-C 2015-2016**	**Percentage change in numbers of students obtaining a grade A*-C 2015-2016**
Chemistry	Total	2,334	76.2%	1,779	2,304	74.5%	1,716	-62	-3.5%
	Male	1,259	74.2%	934	1,205	73.4%	884	-50	-5.3%
	Female	1,075	78.6%	845	1,099	75.8%	833	-12	-1.4%
Computing	Total	290	50.7%	147	287	52.6%	151	4	2.7%
	Male	266	50.4%	134	251	53.0%	133	-1	-0.8%
	Female	24	54.2%	13	36	50.0%	18	5	38.4%
ICT	Total	848	45.2%	383	888	43.1%	383	-1	-0.1%
	Male	544	40.3%	219	543	38.7%	210	-9	-4.1%
	Female	304	53.9%	164	345	50.1%	173	9	5.5%
Mathematics	Total	3,735	80.7%	3,014	3,719	80.2%	2,983	-32	-1.0%
	Male	2,250	80.4%	1,809	2,225	78.9%	1,756	-53	-3.0%
	Female	1,485	81.0%	1,203	1,494	82.3%	1,230	27	2.2%

Table 5.10: Continued

Further mathematics	Total	514	90.7%	466	502	90.2%	453	-13	-2.9%
	Male	372	90.6%	337	331	90.9%	301	-36	-10.7%
	Female	142	90.8%	129	171	88.9%	152	23	17.9%
Physics	Total	1,548	68.6%	1,062	1,511	67.5%	1,020	-42	-4.0%
	Male	1,232	67.0%	825	1,196	66.6%	797	-29	-3.5%
	Female	316	74.7%	236	315	70.8%	223	-13	-5.5%
Design and technology/ technology subjects	Total	727	62.6%	455	727	56.4%	410	-45	-9.9%
	Male	460	57.0%	262	436	50.5%	220	-42	-16.0%
	Female	267	72.3%	193	291	65.3%	190	-3	-1.6%
All subjects	Total	36,034	74.3%	26,773	35,537	73.8%	26,226	-547	-2.0%
	Male	16,074	71.1%	11,429	15,509	70.2%	10,887	-541	-4.7%
	Female	19,960	76.9%	15,349	20,028	76.6%	15,341	-8	-0.1%

		2015			**2016**				
N IRELAND		**Total number of students**	**Percentage A*-C**	**Calculated number of students obtaining a grade A*-C**	**Total number of students**	**Percentage A*-C**	**Calculated number of students obtaining a grade A*-C**	**Change in number of students obtaining grades A*-C 2015-2016**	**Percentage change in numbers of students obtaining a grade A*-C 2015-2016**
Chemistry	Total	1,843	85.0%	1,567	1,864	84.0%	1,566	-1	-0.1%
	Male	837	84.9%	711	851	84.5%	719	8	1.2%
	Female	1,006	85.1%	856	1,013	83.6%	847	-9	-1.1%
Computing	Total	168	75.6%	127	245	78.0%	191	64	50.5%
	Male	157	74.5%	117	208	76.9%	160	43	36.8%
	Female	11	90.9%	10	37	83.8%	31	21	210.1%
ICT	Total	1,498	77.5%	1,161	1,479	77.6%	1,148	-13	-1.1%
	Male	934	76.2%	712	854	74.9%	640	-72	-10.1%
	Female	564	79.6%	449	625	81.3%	508	59	13.2%
Mathematics	Total	3,328	87.0%	2,895	3,376	87.1%	2,940	45	1.6%
	Male	1,946	85.9%	1,672	1,920	85.6%	1,644	-28	-1.7%
	Female	1,382	88.7%	1,226	1,456	88.9%	1,294	69	5.6%
Further mathematics	Total	181	92.3%	167	189	96.8%	183	16	9.5%
	Male	128	92.2%	118	140	96.0%	134	16	13.9%
	Female	53	92.5%	49	49	98.0%	48	-1	-2.0%
Physics	Total	1,532	79.5%	1,218	1,414	80.7%	1,141	-77	-6.3%
	Male	1,135	78.9%	896	1,031	78.9%	813	-82	-9.2%
	Female	397	81.1%	322	383	85.6%	328	6	1.8%
Design and technology/ technology subjects	Total	1,022	75.5%	772	987	76.2%	752	-20	-2.5%
	Male	717	78.4%	562	718	84.4%	606	44	7.8%
	Female	305	76.3%	233	269	78.4%	211	-22	-9.4%
All subjects	Total	32,390	83.0%	26,884	31,828	83.4%	26,545	-339	-1.3%
	Male	14,414	81.1%	11,690	14,085	81.5%	11,479	-210	-1.8%
	Female	17,976	84.6%	15,208	17,743	84.9%	15,064	-144	-0.9%

Source: JCQ

In Table 5.10 we provide an analysis by UK nation as well as by gender. Between 2015 and 2016 the proportion of A level candidates gaining A*-C grades remained fairly stable in England, but with notable increases in computing (particularly for females) and decreases in physics (-2.5%) and design and technology (7% drop overall but 13% for females). The proportion gaining A*-C grades in further maths increased by 3%, but almost all of those additional 293 individuals were male.

In Wales the proportion of candidates gaining A level grades at A*-C was lower than in England overall. It was also lower in most STEM subjects, apart from mathematics – for which it was similar – and further maths, where it was slightly higher. The slight declines seen in pass rates for most STEM subjects between 2015 and 2016 were mostly replicated in Wales, including a 10% drop in design and technology. Interestingly, there were some slight increases in top grades amongst female students, even where the total proportion of entrants declined: for example in computing, mathematics and further mathematics.

Northern Ireland, in contrast, had a higher pass rate overall than England, following the pattern for the previous year. This difference was observed across all the subjects studied, to varying extents, and generally the males/female performance trends were maintained in Northern Ireland.

5.5.2 Achievement in the independent sector

The independent sector is responsible for educating around 18% of pupils over the age of 16.[5.61] However, collation and publication of A level entry or results data from students who studied in independent schools is less systematic than for the maintained sector, and analysis tends to rely on samples rather than the whole cohort. Comparative annual results figures are not included here. However, the 2015 edition of this publication, based on data from a sample of independent schools, reported that performance at the top end of the attainment spectrum was higher than in the maintained sector; 18.5% of independent school students gained at least one A* grade, compared with 8% in the maintained sector.

Previous editions have also shown that students attending independent schools are more likely to sit A levels in some of the 'facilitating subjects' referred to earlier in this chapter. For example, students from independent schools accounted for over a quarter of all entries to further mathematics in 2014, and over 18% of physics entries. Independent school students also accounted for over 28% of those achieving A or A* grades in physics, and almost a third of those

reaching this level in further mathematics in 2014. Although there have been improvements in the number of maintained school entrants to these key subjects – especially further mathematics – the differential between the two sectors remains significant in terms of progress to engineering.

5.6 Vocational qualifications

Vocational qualifications at Key Stage 5 constitute an important part of post-16 education, and for many students offer a viable alternative to A levels as a pathway towards higher learning and employment. As indicated in Chapter 7, on entries to higher education, the proportion of 18-year-olds in England with a BTEC qualification who enter higher education through UCAS has been rising steadily in recent years. The proportion with only BTECs as their level 3 qualification has more than doubled since 2008 and the proportion with a mix of A levels and BTECs has risen by nearly four times in that period.[5.62] These qualifications have also played a particularly important role in the widening of participation in higher education socio-economically. A much higher than average proportion of entrants to university who come from family backgrounds of disadvantage, or with no prior history of higher education, have BTEC or similar qualifications, or a mixture of these and A levels. At the same time, more pupils at independent schools are also taking BTEC qualifications.[5.63] UCAS has, however, recently reported that the proportion of high-performing BTEC students (ie those with grades equivalent to ABB at A level) going to university plateaued in 2016. It believes this could relate to recent new limits being placed on which vocational qualifications could be included in school performance measures.

Table 5.11 shows the number of students completing level 3 BTECs in selected STEM subjects from 2005/6 to 2015/16. It should be remembered that this is only one provider of vocational level 3 qualifications, so this is not the entire picture nationally. The numbers in academic science subjects are unsurprisingly very small overall, albeit growing fast. Much more significant are subjects such as engineering and ICT, where participation has grown six-fold over ten years: the number of level 3 BTECs taken in the UK in engineering and ICT by under-19-year-olds now equals the number of A levels taken in mainstream subjects like physics or further mathematics. What is also noticeable, however, is the very low proportion of female participants in these subjects: engineering, in particular, was only 5% female.

If anything, these two subjects have grown more strongly than BTECs across all subjects: engineering and ICT make up around one fifth of all BTEC completions at level 3. They are now a key element in the qualifications pipeline into the high-skilled engineering labour force via higher and further education. This growth in level 3 participation, both in key vocationally-oriented subjects like engineering and ICT, and overall, is in contrast to the general decline in vocational qualifications at level 2 (as we will see in Chapter 6 on further education).

The proportion of these qualifications being taken by under 19s has been growing steadily, reflecting their increasingly widespread use in post-16 education in school sixth forms and colleges.

5.61 Independent Schools Council: *Research* (web page). http://www.isc.co.uk/research/ **5.62** UCAS: *End of cycle report*, December 2015. https://www.ucas.com/sites/default/files/eoc-report-2015-v2.pdf **5.63** Irena Baker: *Fewer students with higher grades at BTEC going to university, figures show* (Times Educational Supplement website), September 2016. https://www.tes.com/news/school-news/breaking-news/fewer-students-higher-grades-btec-going-university-figures-show

Table 5.11: Number of students completing selected STEM BTEC subjects at level 3, by gender and age (2005/6-2015/16) – all domiciles

		2005/6	2006/7	2007/8	2008/9	2009/10	2010/11	2011/12	2012/13	2013/14	2014/15	2015/16	Change over 1 year	Change over 10 years
Biology	Total	76	129	145	291	730	760	499	610	658	708	712	1%	837%
	% UK	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%		
	% aged under 19	63%	69%	67%	80%	85%	86%	86%	84%	86%	86%	89%	3%p	26%p
	% female	63%	58%	55%	54%	52%	52%	54%	60%	61%	62%	63%	1%p	0%p
Chemistry	Total	13	23	27	82	82	68	53	56	70	22	33	50%	154%
	% UK	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%		
	% aged under 19	15%	13%	37%	57%	62%	82%	62%	66%	63%	82%	42%	-40%p	27%p
	% female	62%	30%	44%	44%	35%	44%	43%	41%	49%	68%	33%	-35%p	-29%p
Physics	Total	3	2	18	32	28	31	16	21	36	75	134	79%	4367%
	% UK	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%		
	% aged under 19	33%	50%	33%	53%	50%	90%	94%	62%	81%	83%	85%	2%p	53%p
	% female	0%	100%	39%	38%	29%	16%	13%	19%	36%	27%	24%	-3%p	24%p
Other science	Total	1,816	2,281	2,772	3,727	5,584	8,806	12,366	17,584	21,524	24,814	26,243	6%	1345%
	% UK	100%	100%	99%	99%	100%	100%	100%	100%	100%	100%	100%	0%p	0%p
	% aged under 19	29%	36%	39%	47%	56%	61%	70%	72%	76%	76%	78%	2%p	47%p
	% female	61%	59%	55%	58%	55%	54%	53%	53%	54%	55%	55%	0%p	-6%p
Engineering	Total	4,198	4,360	4,779	5,900	7,437	7,589	9,600	13,155	16,076	17,657	24,439	38%	482%
	% UK	91%	96%	97%	98%	99%	99%	97%	99%	97%	99%	97%	-2%p	6%p
	% aged under 19	34%	43%	47%	47%	43%	46%	53%	58%	60%	61%	58%	-3%p	24%p
	% female	5%	4%	4%	4%	4%	4%	4%	4%	5%	5%	7%	-5%p	2%p
ICT / computing	Total	6,993	8,936	11,249	14,707	17,011	20,658	26,019	32,837	38,138	39,725	38,492	-3%	450%
	% UK	91%	94%	97%	97%	98%	99%	97%	99%	99%	100%	99%	-1%p	8%p
	% aged under 19	48%	48%	49%	51%	53%	58%	63%	68%	72%	74%	73%	-1%p	25%p
	% female	15%	15%	15%	16%	16%	17%	18%	17%	17%	16%	16%	0%p	1%p
Construction	Total	2,605	3,004	3,647	3,990	3,994	3,133	3,548	3,842	3,861	3,911	4,548	16%	75%
	% UK	99%	96%	98%	99%	99%	99%	99%	99%	97%	95%	95%	0%p	-4%p
	% aged under 19	35%	36%	40%	42%	43%	45%	46%	47%	46%	45%	45%	0%p	10%p
	% female	11%	12%	11%	11%	9%	9%	8%	8%	8%	8%	9%	1%p	-2%p
All subjects	Total	88,663	108,942	126,436	150,306	181,569	212,749	258,444	316,917	347,278	359,340	343,874	-4%	288%
	% UK	98%	98%	98%	99%	99%	99%	99%	99%	99%	99%	99%	0%p	1%p
	% aged under 19	50%	52%	54%	58%	59%	62%	66%	69%	72%	74%	75%	1%p	25%p
	% female	44%	44%	44%	45%	45%	45%	45%	45%	45%	45%	45%	0%p	1%p

Source: Pearson

5.7 Scottish post-16 qualifications

Highers and Advanced Highers are single year course qualifications, roughly equivalent to AS and A levels. They are distinct from each other in the same way that new A levels in England are decoupled from new AS levels. Many students take four or five Highers, which is the predominant route into Scottish higher education. Alternatively, they may choose to study for an additional year and sit Advanced Higher examinations: students with two or three Advanced Highers are able to enter directly into the second year of an honours degree or be exempted from certain subjects during the first year.

Scottish students sat the newly introduced Highers and Advanced Highers examinations for the first time in 2015 and 2016 respectively. As it tends to take some time for new qualifications to bed in, we have not attempted comparisons with similar qualifications from previous years.

Table 5.12 shows the number of entries to the new Higher qualifications for selected subjects in 2015 and 2016 and the proportion of students achieving an A grade (which is roughly equivalent to an A level at grade A-C). Substantial growth in entrants can be seen in some key subjects, compared with 2015, reflecting the phasing in of the new qualification. As expected from a new qualification, there is relatively high volatility in the proportions achieving an A grade in certain subjects between 2015 and 2016, particularly where entry numbers were low. The proportion gaining an A grade overall was 77% (below the 2015 level). Proportions in the key STEM subjects were generally lower than this, to some extent mirroring the trend seen in A level attainment.

First results from those sitting the new Advanced Higher qualifications in 2016 are shown in Table 5.13. The proportion gaining A grades across all subjects was slightly greater than for Highers, at nearly 82%: again, mirroring A level and AS level trends. A grade achievement rates in physics and especially mathematics were lower than overall. However, the data should be treated with caution as the numbers of entrants were very small for some subjects.

Table 5.12: Attainment in selected STEM Higher qualifications (2015-2016) – Scotland

Subject		2015	2016
Biology	Total entries	2,572	7,493
	Percentage A grade	26.3%	24.0%
	Number A grade	677	1,799
Administration and IT	Total entries	3,025	3,965
	Percentage A grade	42.8%	30.6%
	Number A grade	1,296	1,212
Chemistry	Total entries	4,020	10,077
	Percentage A grade	22.0%	29.6%
	Number A grade	885	2,981
Computing science	Total entries	1,182	4,454
	Percentage A grade	16.1%	19.9%
	Number A grade	190	886
Design and manufacture	Total entries	2,224	3,078
	Percentage A grade	18.7%	14.2%
	Number A grade	416	437
Engineering science	Total entries	881	1,029
	Percentage A grade	25.9%	21.9%
	Number A grade	228	225
Fashion and textile technology	Total entries	213	305
	Percentage A grade	48.4%	33.4%
	Number A grade	103	102
Health and food technology	Total entries	943	1,449
	Percentage A grade	21.1%	20.3%
	Number A grade	199	294
Mathematics	Total entries	10,220	18,868
	Percentage A grade	19.7%	30.8%
	Number A grade	2,015	5,811
Music technology	Total entries	280	486
	Percentage A grade	47.5%	54.5%
	Number A grade	133	265
Physics	Total entries	3,662	9,131
	Percentage A grade	23.5%	28.0%
	Number A grade	862	2,553
All subjects	Total entries	107,295	197,774
	Percentage A grade	29.3%	29.2%
	Number A grade	31,491	57,688

Source: SQA

Back to Contents

Table 5.13: Attainment in selected STEM Advanced Higher qualifications (2015-2016) – Scotland

Subjects		2016
Biology	Total entries	2,362
	Percentage A grade	80.3%
	Number A grade	1,896
Chemistry	Total entries	2,614
	Percentage A grade	82.9%
	Number A grade	2,168
Computing science	Total entries	485
	Percentage A grade	74.6%
	Number A grade	362
Engineering science	Total entries	75
	Percentage A grade	77.3%
	Number A grade	58
Health and food technology	Total entries	25
	Percentage A grade	72.0%
	Number A grade	18
Mathematics	Total entries	3,356
	Percentage A grade	73.8%
	Number A grade	2,476
Mathematics of mechanics	Total entries	222
	Percentage A grade	73.9%
	Number A grade	164
Physics	Total entries	1,923
	Percentage A grade	78.9%
	Number A grade	1,518
All subjects	Total entries	23,795
	Percentage A grade	81.7
	Number A grade	19,443

Source: SQA

5.8 The teaching workforce

5.8.1 Teacher workforce in England

Table 5.14 shows the headcount of teachers in maintained secondary schools in England and the STEM subjects and level that they teach. (It should be noted that this is to some extent a partial view of the total teaching workforce: although it includes both qualified and unqualified teachers who work part or full-time, it excludes those employed in independent schools and sixth form colleges.)

In 2015, there were 226,500 teachers serving Key Stages 3 to 5 in England, below 2010's total of 239,800 (and slightly below the 229,000 reported in 2014).[5.64] The data also show that many of the teachers are deployed to teach at several key stages. On this basis, there were 33,700 teachers of mathematics at these levels in 2015, compared with 33,000 in 2010. The 36,000 teachers of science in 2015 cannot be directly compared with previous years since no figures are available. However, the number teaching combined science declined by around 1,000 over this period, and this is the largest constituent of the total number of science teachers.

These changes should be set in the context of GCSE science entry numbers for the UK, which have been growing slightly (0.6%) over the last five years, while Table 5.14 shows that the number of combined science teachers has fallen over broadly the same period. In contrast, the number of mathematics teachers has grown slightly (Table 5.14: from 33,000 in 2010 to 33,700 in 2015) while the number of GCSE mathematics entrants fell slightly (Table 5.1: down 2% over five years).

Conversely, the (albeit much smaller) numbers of teachers for the individual sciences of physics, chemistry and biology have grown since 2010. However, it is of some concern that although the number of entrants for GCSE are very similar for each of these subjects (at over 130,000 across the UK in 2016 – Table 5.1), the 2015 figures in Table 5.14 show that the number teaching physics (6,300) was significantly lower than the number teaching chemistry (7,500) and especially biology (8,700).

The decreases in the numbers teaching design and technology and ICT have been much more substantial over the five-year period. There has been a significant decline in the number of entries to GCSE in design and technology over the same period, so a decrease in the number of design and technology teachers may be in line with this. However, the numbers entering ICT or computing over the same period have risen strongly, so a decrease in the teacher workforce delivering ICT and/or computing subjects is of more concern. It is worth noting that DfE is currently recommending to the Home Office that secondary school teachers in computer science and design and technology (and Mandarin) should be added to the shortage occupation list. This would make these roles available to immigrants from outside Europe (in addition to teachers of mathematics, physics and chemistry, which are currently on the shortage occupation list).[5.65]

The DfE and the Institute of Physics estimate that around 1,000 new physics teachers need to be recruited every year for at least the next decade in order to fulfil projected demand. However, comparison of year-on-year statistics suggests that the number teaching physics as a single subject is only changing by around 100 per year, and actually fell by 100 between 2014 and 2015.[5.66] In response to the shortages of physics and mathematics teachers, the English government has been trying to boost numbers by offering subject-specific training to non-specialist science teachers, delivering more new mathematics and physics teachers by attracting new graduates and trying to bring former teachers back into the classroom as well as retraining mid-career professionals in related sectors.[5.67] Additional financial incentives are being offered to increase the number of STEM graduates who enter as newly qualified teachers, in return for a commitment to teach for three years after graduation. New physics degrees are also being piloted that will allow students to obtain a teaching qualification in addition to their degree course.

5.64 EngineeringUK: *The state of engineering 2016*, January 2016. http://www.engineeringuk.com/Research/ **5.65** Migration Advisory Committee: *Call for evidence: partial review of the shortage occupation list: teachers*, June 2016. https://www.gov.uk/government/consultations/migration-advisory-committee-mac-review-on-teacher-shortages **5.66** EngineeringUK: *ibid* **5.67** DfE: *Statistics: school workforce*, November 2015. https://www.gov.uk/government/collections/statistics-school-workforce

Table 5.14: Number of teachers of STEM subjects in maintained secondary schools in England, by Key Stage (2010 and 2015)[5.68]

		2015				2010			
		Total	Key stage 3	Key stage 4	Key stage 5	Total	Key stage 3	Key stage 4	Key stage 5
Mathematics		33,700	33,500	29,100	13,100	**33,000**	29,400	27,400	12,400
Physics		6,300	1,500	3,700	4,400	**5,600**	1,100	2,900	4,200
Chemistry		7,500	1,600	4,100	5,400	**6,700**	1,100	3,200	5,300
Biology		8,700	1,700	4,500	6,600	**8,400**	1,200	3,500	6,900
Combined / general science		32,100	28,800	25,500	3,000	**33,300**	29,900	27,600	2,600
Other sciences		2,100	500	1,000	1,200	**2,700**	500	1,700	1,100
Sub-total sciences		**36,000**	**31,000**	**31,200**	**18,400**	-	-	-	-
Design & technology		11,500	5,500	9,200	3,000	**15,000**	6,000	12,400	3,700
	of which:								
	Electronics / systems and control	900	400	600	200	**1,300**	500	900	300
	Food technology	4,500	2,400	3,300	700	**5,300**	2,300	4,100	800
	Graphics	3,000	1,100	2,100	800	**4,000**	1,200	3,000	900
	Resistant materials	3,700	1,600	2,800	500	**4,500**	1,700	3,500	600
	Textiles	2,700	1,100	1,900	1,000	**3,400**	1,100	2,600	1,300
Other / combined technology		13,800	12,600	3,300	2,400	**16,300**	15,100	3,900	2,700
Engineering		1,500	300	1,100	600	**1,500**	200	1,300	500
ICT		13,100	10,800	8,400	4,700	**18,400**	15,700	13,000	5,800
Total		**226,500**	**199,800**	**198,000**	**116,100**	**239,800**	**212,600**	**211,900**	**119,700**

Source: DfE

Figure 5.1 shows the highest post-A level qualifications held by STEM subject teachers in English maintained secondary schools in 2015. These are in large part very similar to the qualifications profiles observed in the previous year. Figure 5.1 demonstrates that, for example, almost 78% of those teaching biology had a degree in that subject, whereas this was the case for only 51% of those teaching physics, and 45% mathematics. This is concerning, as research conducted by the Education and Training Foundation found that over 40% of mathematics teachers lacked confidence in teaching all elements of GCSE mathematics: those with a mathematics or mathematically-oriented degree had far higher confidence when asked difficult questions by pupils.[5.69]

Interestingly, far fewer of those teaching the more 'vocationally focused' subjects of ICT and engineering (the latter admittedly a minor subject numerically) had a degree in that subject.

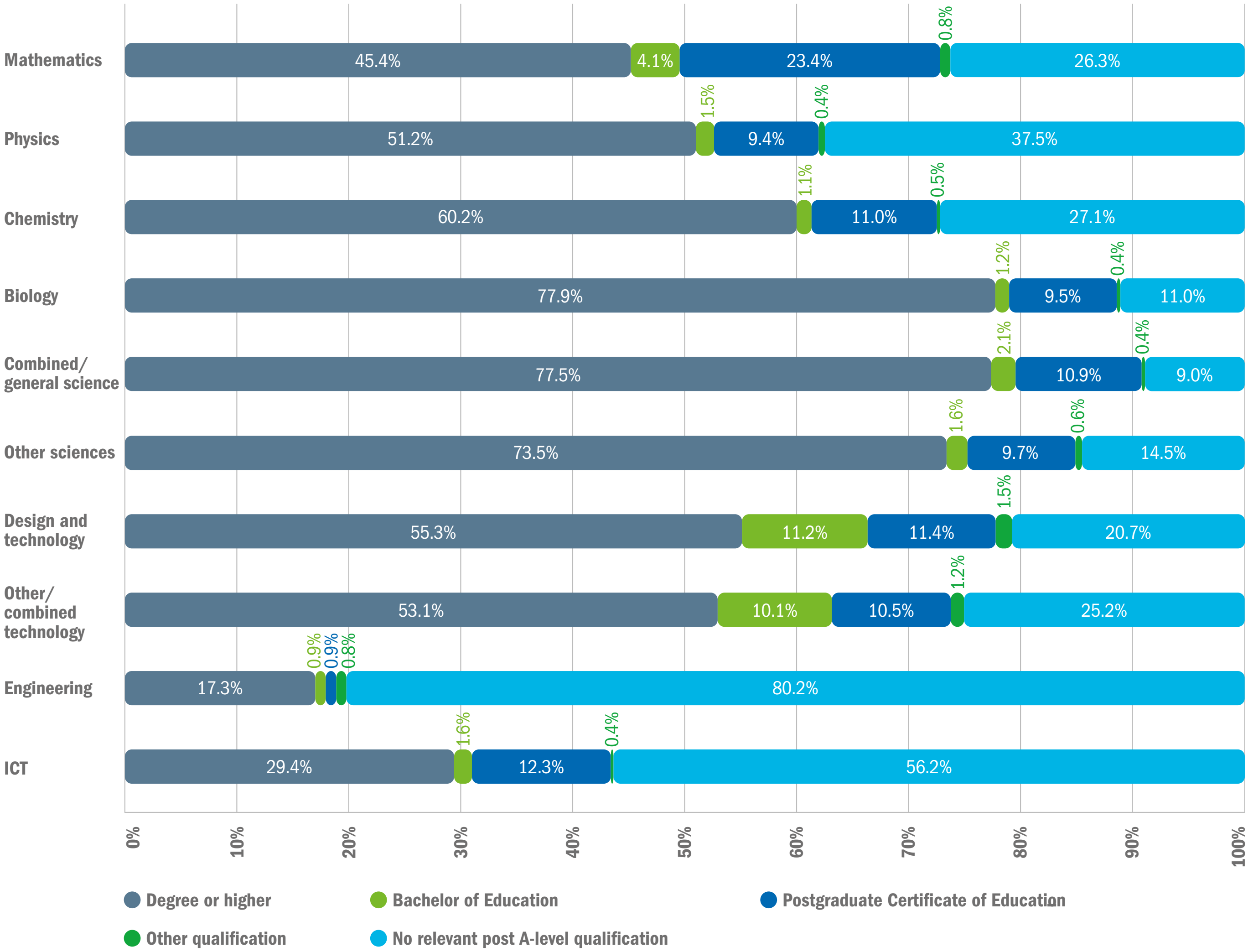
Research by the Sutton Trust has shown that secondary-level independent school teachers (not included in Figure 5.1) are more likely than state school teachers to have graduate or postgraduate qualifications relevant to the subjects they teach. This has especially been true in some of the subjects in which there are shortages of teachers, such as physics and mathematics.[5.70]

5.8.2 Teacher workforce in Wales

A more general measure of subject specialism is used for teachers in Wales than in England, where the highest level qualification subject is considered (Table 5.14). However, Table 5.15 indicates the number of secondary school teachers registered with the General Teaching Council Wales for each STEM subject who have been trained in that subject. Encouragingly, over three quarters of current mathematics teachers are trained in that subject – a proportion that has risen over the last five years by 200 teachers. The proportions of subject-trained teachers of individual sciences have also risen during this period, although less markedly. At 44%, physics still has the lowest proportion of specialist teachers, and numbers fell between 2015 and 2016. The proportion of combined science teachers with specific science training also remains low, although numerically they outnumber those teaching single subjects.

5.68 Teachers were counted once against each subject that they were teaching, regardless of the amount of time spent teaching that subject, and counted under each key stage they were recorded as teaching to. They are only counted once in the 'subtotal sciences' row. **5.69** Frontier economics: *The qualifications of English and mathematics teachers – Report prepared for the Education and Training Foundation* (ETF) September 2014 (p19). http://www.et-foundation.co.uk/wp-content/uploads/2014/09/RPT-Survey-v4.pdf **5.70** Dr Philip Kirby: *Teaching by degrees – the university backgrounds of state and independent school teachers* (The Sutton Trust) 2015, (p4). http://www.suttontrust.com/wp-content/uploads/2015/06/Teaching-by-Degrees.pdf

Figure 5.1: Highest post A level qualifications held by publicly-funded secondary school teachers (head count) in the STEM subjects they taught (2015) – England[5.71, 5.72, 5.73, 5.74]



Source: School Workforce Census

Table 5.15: Number of registered school teachers by STEM subject taught, and whether trained in subject – Wales maintained secondary schools (2011, 2015, 2016)

	2011			2015			2016				
	Total teaching subject	Percentage known to be trained in subject	Number known to be trained in subject	Total teaching subject	Percentage known to be trained in subject	Number known to be trained in subject	Total teaching subject	Percentage known to be trained in subject	Number known to be trained in subject	Difference in number of subject-trained teachers	
										Over 1 year	Over 5 years
Biology	459	53.8%	247	431	56.6%	244	427	58.5%	250	6	3
Chemistry	438	45.9%	201	411	51.6%	212	419	52.7%	221	9	20
Mathematics	1,451	68.7%	997	1,477	77.9%	1,151	1,530	77.6%	1,187	37	190
Physics	400	41.3%	165	373	45.3%	169	367	44.1%	162	-7	-3
Science	1,185	27.8%	329	1,147	33.2%	381	1,151	30.6%	352	-29	23

Source: EWC[5.75]

5.71 Where a teacher has more than one post A level qualification in the same subject, the qualification level is determined by the highest level reading from left (degree or higher) to right (other qualification). For example, teachers shown under PGCE have a PGCE but not a degree. 5.72 Not including qualifications in Special Educational Needs provision. 5.73 Teachers are counted once against each subject which they are teaching. Head counts are used, so a teacher teaching French and German would be counted once in each. 5.74 Other qualification: includes Certificate of Education, Non-UK Qualifications where the level was not provided and other qualification at National Qualifications Framework (NQF) level 4 or 5 and above e.g. diplomas or higher education and further education, foundation degrees, higher national diplomas and certificates of higher education. 5.75 Education Workforce Council: *Annual statistics digest 2016*, March 2016. http://www.ewc.wales/site/index.php/en/documents/research-and-statistics/annual-statistics-digest/84-ewc-annual-statistics-digest-2016

5.8.3 Teacher workforce in Scotland

The statistics recorded in Scotland are somewhat different in nature. Table 5.16 shows that the number of mathematics, general science and physics teachers (excluding head teachers and deputy heads) in maintained Scottish secondary schools has been falling over the last five years, but numbers have remained stable for the rest of the separate sciences. Encouragingly, the data shows that the main teaching subject of a high proportion of teachers is the one that they trained in. In physics, 90% of teachers with an educational background in physics are teaching physics as their main subject. In mathematics, this figure is 94%. In chemistry and biology, the figure is around 85%. All of these figures are well above the all-subject average of just under 73%.[5.76]

5.9 Improving gender balance in subject choices: the magic 30%

Written by Charles Tracy, Institute of Physics

This article is a follow up to Peter Main's piece that appeared in the 2015 *The state of engineering* report.[5.77] It includes findings of a group of Institute of Physics (IOP) projects that have produced some revelatory observations and potentially transformational results. In one group of schools, the proportion of girls taking AS level physics has nudged 30% – which is significant because that is seen by some as the tipping point in any cultural change. The main finding, from all the projects, is that gender imbalances need to be tackled at a whole-school level.

5.9.1 Background

As Peter highlighted in his article, the proportion of A level physics students who are girls has remained relatively static at around 22% for the last 30 years. In that time, the number of A level physics students in the UK dropped from 47,000 in 1989 to 27,000 in 2006 and then rose again by 34% in the eight years to 2014; so the static 22% was within a hugely variable overall climate. Despite many interventions, including some from the IOP, the problem (ie the under-representation of girls) has apparently remained unsolved. The most common type of intervention has generally been some kind of outreach or marketing – ie visits, videos, lectures and literature; and in some cases there have been activities specifically designed for girls.

Table 5.16: Number of secondary school teachers in STEM subjects, and whether main subject taught (2010, 2014, 2015) – Scotland

	2010			2014			2015		
	Main subject taught	Total	Proportion teaching main subject	Main subject taught	Total	Proportion teaching main subject	Main subject taught	Total	Proportion teaching main subject
Mathematics	2,644	2,827	93.5%	2,404	2,567	93.7%	2,350	2,500	94.0%
Biology	1,162	1,364	85.2%	1,180	1,364	86.5%	1,165	1,340	86.9%
Chemistry	936	1,101	85.0%	936	1,114	84.0%	932	1,104	84.4%
Physics	868	954	91.0%	824	909	90.6%	807	896	90.1%
General science	143	2,086	6.9%	129	1,833	7.0%	128	1,738	7.4%
Computing studies	699	-	-	636	-	-	601	875	68.7%
All subjects	23,177	33,137	69.9%	21,963	30,705	71.5%	21,590	29,714	72.7%

Source: Scottish Government

5.76 Scottish government: *Teacher census 2015, supplementary data*, February 2016. http://www.gov.scot/Topics/Statistics/Browse/School-Education/teachcenssuppdata/teachcensus2015 **5.77** Peter Main: *More girls, more teachers, more engineers*. In EngineeringUK: The state of engineering, 2015, p106 http://www.engineeringuk.com/EngineeringUK2015/EngUK_Report_2015_Interactive.pdf

One exception was the work of the Stimulating Physics Network to support physics teachers with their classroom and lesson management. This led to some notable gains, but they were not transformational. The proportion of girls seemed to hit a brick wall at around 25%. This work confirmed that the girls' experience in the physics classroom is important. And that improving that experience – by working with teachers – is an important part of the solution, but not the whole solution.

5.9.2 Whole-school differences

The whole solution required more investigation. Therefore, the IOP followed up with two further, statistical, reports: 2012's *It's different for girls*[5.78] and 2013's *Closing doors*.[5.79] These suggested that there was a cultural barrier to the choices girls were making at 16 and this barrier was most evident in mixed, state-maintained schools. In this sector, girls were 5.5 times less likely to take A level physics than boys, whereas in other school sectors (most notably single-sex independent schools), they were 2.6 times less likely (Figure 5.2).

The inference was that there was some combination of influences in mixed maintained schools that was having an effect on pupils' choices and, specifically, that this effect was gendered: it was more marked for girls and in relation to physics. If the differences between the sectors had not been gendered, then the participation rate of 1.8% (for girls in mixed maintained schools) would have been more like 3.6%.

As an aside, the differences were also more marked for boys in relation to psychology, drama and modern foreign languages.

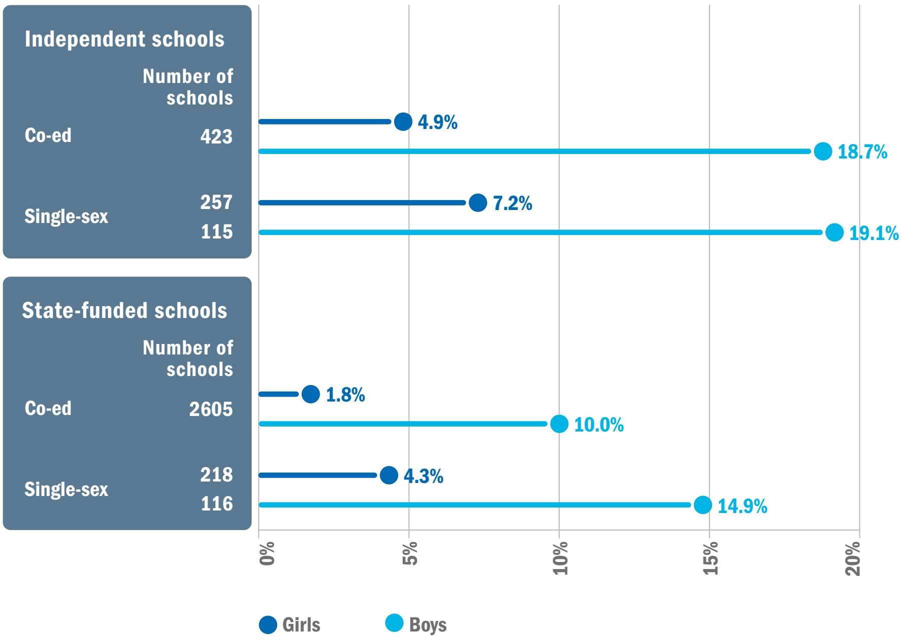
In broad terms, in mixed maintained schools, one might have expected more than twice as many girls to be choosing A level physics. Although 3,138 girls from mixed maintained schools did choose A level physics in 2013, a further 3,000 or so girls might have taken physics but, due to adverse influences, chose not to.

5.9.3 Looking deeper

As a result of these statistical findings, the IOP embarked on three new projects to investigate and address whole-school issues: Improving Gender Balance (funded by the Department for Education), Opening Doors (funded by the General Equalities Office) and a project funded by the Drayson Foundation, known as Strand D. The projects have revealed a great deal about the mechanisms that create an environment that leads to gendered choices. The basis of the projects has been to identify, challenge and remediate all aspects of gender bias – whether conscious or unconscious – within the school environment.

The first phase of the projects was to carry out observations within schools to identify examples of stereotyping or bias. Much of this was within the Opening Doors Project – which was built around school-to-school visits between 10 schools in two clusters.

Figure 5.2: Percentages of girls and boys who went on to take A level physics by type of school (2011)



Source: Institute of Physics

Early findings in schools

One early finding was that sexist language, although prohibited, tended to be tolerated more than homophobic or racist language. There were even examples of open sexist bullying with girls being put down for answering questions (this was very noticeable in physics lessons). A typical comment from a year 12 girl was, "In my lessons, I feel that it is too male-dominated. I'm not able to voice my opinion on a physics concept without worrying I will be wrong."

Also prevalent were subtle biases – often unconscious but, again, fairly open. Many schools were not aware of how unconscious bias could lead to stereotypical treatments of students or the problems that this stereotyping could cause. In some schools, the fact that the uptake of A levels was gendered was simply taken as conforming to normal behaviour and nothing to worry about – a form of stereotyping in its own right.

There were frequent examples of school publications – especially those relating to careers and subject choices – that had a gendered feel to them. In some schools there was a gendered edge to some of the advice that was being given to pupils too.

In rare cases, there were overt expressions of surprise if girls were choosing physics. More commonly, certain subjects were presented as more or less difficult, and a view that physics and maths are subjects in which success is solely (or largely) based on raw ability. The phrase often used was: "you can either do it or you can't." In contrast, other subjects were portrayed as rewarding hard work, application and perseverance – an attitude that has been shown to have a gendering effect.[5.80] There was also little awareness that girls and boys might respond differently to these messages.

Much of this is summed up by a comment from a headteacher on the radio during the launch of the *Closing doors* report. The head stated that: "Girls prefer to take biology [rather than physics] because it develops softer skills." There is much to analyse in this comment and we should not demonise an individual. However, in brief, this comment betrays, at the very least, a naïve, patronising and undervaluing view of all three of its subjects: girls, physics and biology. And it illustrates the sort of biased messages that can be the daily diet for girls (and boys) in society and in many schools.

One thing was certain from all of this work: the experiences that girls and boys have in playgrounds, classrooms, in the advice they are given and in the messages they hear about their choices and their futures, are relentlessly different.

5.78 Institute of Physics: *It's different for girls – the influence of schools*, 2012. https://www.iop.org/education/teacher/support/girls_physics/file_58196.pdf **5.79** Institute of Physics: *Closing doors: exploring gender and subject choice in schools*, 2013. http://www.iop.org/publications/iop/2013/closingdoors/ **5.80** Sarah-Jane Leslie et al.: *Women's participation and attitudes to talent* (Science, 347 (6219) pp262-265). http://science.sciencemag.org/content/347/6219/262

Back to Contents

Figure 5.3: Essential features of good practice in countering gender stereotyping in schools

Essential features of good practice in countering gender stereotyping in schools

Based on the discussions and observations that took place within the site visits and subsequent recommendations given to schools, the following are the essential features of a school that is actively addressing gender equity.

1 **Senior gender champion**
Senior Leadership Teams identify one of their number as a gender champion whose role includes bringing together the whole school in a coherent campaign to challenge gender stereotypes. Governors are involved in the campaign in order to reinforce the message that this activity is a priority.

2 **Training**
Staff attend gender awareness and unconcious bias training, whether as part of their induction to the school or their ongoing professional development.

3 **Sexist language**
Sexist language is treated as being just as unacceptable as racist and homophobic language. Teachers receive training on unconscious bias and equality and diversity awareness.

4 **Use of progression data**
Gender-disaggregated data on both achievement and progression are collected for all subjects and discussed formally at whole-school level, using benchmark data for comparison. Where there are issues to be addressed, actions are generated, including targets where appropriate.

5 **Initiatives**
Initiatives are introduced and developed on the basis of what works and in a way that shows how the address a problem identified in the school data. Carefully planned external visits encourage students to challenge stereo- typical views as do role models who commit to developing sustainable relationships.

6 **Subject equality**
There is a strict policy that all subjects are presented equally to students in terms of their relative difficulty and teachers refrain from making any remarks about how difficult they find particular subjects. The emphasis is on working to the best of one's ability rather than seeking to find subjects where one have innate talents.

7 **Careers guidance**
Careers guidance starts an early stage. It focuses on the next educational phase, emphasises keeping options open and activity challenges gender stereotypes.

8 **Student ownership**
Students are at the heart of any campaign to counter gender stereotyping. They are made aware of the issues and be encouraged to think of ways of combatting them.

9 **Personal, social, health and economic education**
Regularly timetabled PSHE sessions are regarded as a high-value activity that can have a positive impact on student's lives, teachers delivering content are provided with resources and activities. Sessions on equality and diversity form the basis of a wider school campaign and discussions on these themes continue through other topics.

Source: Institute of Physics

5.9.4 Outputs from *Opening Doors*

As a result of these observations, the IOP published the *Opening doors*[4.81] report in October 2015. Within the report is a summary of the features of schools that are likely to have less gendering within their subject choices (Figure 5.3).

5.9.5 Addressing the problem differently

In parallel with (and informed by) the Opening Doors project, the IOP set up the Improving Gender Balance and Drayson pilot projects working in 20 schools.[5.82] There were three strands to these projects. Table 5.17 describes the strands and summarises the results. In all the strands, there were reported benefits and increases in the numbers taking AS level physics. However, it was in Strand D – the combined approach – that the results were potentially transformational: across the six pilot schools there was a 333% increase in the number of girls choosing AS physics and the proportion of girls in the AS groups rose to nearly 30% (up from 10% two years earlier).

Some of the teachers' responses were very illuminating:

"I didn't think about gender issues so they were probably male-oriented lessons."
– Teacher in Strand B school

"We want pupils to be aware that there is gender stereotyping around them and to be able spot that and make informed choices."
– PSHE teacher

"We noticed that boys tended to dominate classroom discussions and answering questions. We have started to address this."
– Teacher in Strand C school.

The most pleasing thing is the growth in confidence. For example, there were two girls who in year 10 science wouldn't get involved and took a back seat. But now they have got more confidence and have changed their attitude to science. They seek help in physics where before they wouldn't have asked. – Teacher in Strand A school

5.9.6 Whole-school work is the key to opening doors

From these results, it is clear that work with girls and with physics teachers is necessary. However, it is also essential to unblock the barriers that are put up by society and, unconsciously, by schools. A more positive metaphor, now adopted by the IOP, is opening doors. And the key to unlocking those doors is working with the whole school staff on reducing unconscious biases and gender stereotyping. For example, in Strand A, girls' awareness and resilience would be raised by the intervention but this effort is squandered if they still feel, through cultural and school expectations, that some doors are closed to them. Similarly, in Strand B, the physics lessons became more inclusive but the sense of closed doors within the school remained, limiting the reach of this good work.

It is worth making the point here that the whole-school work is not solely about increasing A level physics numbers. It is about social equity and giving all students (boys and girls) access to the routes that they want to follow without presenting them with the perception of closed doors based on their gender (whether that is physics for girls or languages and drama for boys). In Strand D (the whole-school pilot project), the project officers were completely subject neutral – ie their activities were about

Table 5.17: Summary of IOP project strands and findings

Strand	Findings
A: Ambassador working with girls to improve their confidence and resilience	● High impact on girls involved (but small number of girls) ● Increase in confidence and transferrable skills
B: Teaching and learning coach supporting science teachers with inclusive teaching techniques	● Increase in uptake (similar to earlier results in Stimulating Physics Network) ● Increase in awareness amongst teachers of problem ● Teachers reported more inclusive teaching
C: Gender balance	● Increase in use of data by schools ● Increased awareness of gender stereotyping – especially relating to careers ● Teachers and pupils felt empowered to bring about change
D: (Drayson project): combining the strands.	● Transformational change in numbers across the 6 pilot schools ● The number of girls choosing physics rose from 12 to 52 ● The proportion of girls rose from 10% to 29%

Source: Institute of Physics

5.81 Institute of Physics: Opening Doors: A guide to good practice in countering gender stereotyping in schools, October 2015. http://www.iop.org/publications/iop/2015/page_66430.html 5.82 Institute of Physics: *Improving Gender Balance* (web page). http://www.iop.org/education/teacher/support/girls_physics/improving-gender-balance/page_63795.html and *Drayson Girls in Physics Pilot Project* (web page). http://www.iop.org/education/teacher/support/girls_physics/drayson/page_63799.html eliminating gender effects at a whole-school level rather than promoting physics as a route. The fact that more girls then chose physics was related to them being able to make a freer choice in a less biased environment; ie they were not encouraged to choose differently, rather, they were freed to choose as they preferred.

5.9.7 Next steps: continuing to open doors

The next stage is to try to scale up the success of the pilot in the Drayson project by providing an incentive for schools to address gender biases and by developing a workforce of supporters who can provide professional development for schools to help them address those issues. Taking these in reverse order:

Professional development

In 2016/17, the IOP will be rolling out the findings with direct whole-school support from available partners schools in the Stimulating Physics Network. At the same time, the Project Officers will develop a new network of in-school CPD leaders who can support local schools in challenging gender biases at a whole school level. The intention is that, in three years' time, there will be training and support capacity in the system to work with other organisations to effect change across the system.

A gender equity mark

In order to provide reward and incentives for schools who take part in addressing gender issues in their school, the IOP, in partnership with King's College and UCL Institute of Education, is developing a Gender Balance Mark – with a set of principles based on the Opening Doors recommendations above. Rather like Project Juno,[5.83] which works in university departments, it is likely that that there will be three levels to the Mark: one for signing up to the principles, one for addressing them and one for being a champion. This Gender Balance Mark is being piloted in London this year and will be rolled out nationally within the next two years. We are looking for partnership and support from interested organisations.

5.9.8 Summary

In summary, the findings of the pilot projects show convincingly that, to improve gender balance, we have to address unconscious bias and stereotyping across the whole school. By doing so, it is possible to make transformational improvements to the gendering of subject choices. Therefore, the IOP is developing a workforce of trainers who can implement the findings nationally and, at the same time, developing a reward scheme for those schools that engage in making all doors open to all pupils regardless of their gender.

5.83 Institute of Physics: *Project Juno* (web page). http://www.iop.org/policy/diversity/initiatives/juno/index.html

Part 2 – Engineering in Education and Training
6 Apprenticeships and further education

Key points

An evolving landscape

The current emphasis in education and skills policy is firmly on apprenticeships rather than further education (FE), resulting in a feeling that the FE sector is at something of a crossroads. More restructuring of qualifications frameworks is aiming to simplify the vast array of qualifications but is resulting in new pathways and qualification groupings.

Meanwhile the number of vocational qualifications obtained in FE colleges is falling, and the total number of colleges is slipping due to mergers and closures. Within this declining picture the number of engineering-related vocational qualifications obtained is actually rising, especially at the higher levels desired in pathways that lead towards a higher skilled technical labour force.

Participation in apprenticeships

The government has loudly stated its ambitious plans for growth in apprenticeships, seeking three million starts during this parliament:

- There was a 15% growth in total starts in England in the year to 2014/15 and in that year 108,000 in engineering sectors, the highest for ten years;
- Engineering-related apprenticeships are most populous in the North West, West Midlands and South East England, but least common in London;
- 58,000 engineering related apprenticeships were achieved in England in 2014/15, 42% of them at level 3 or above, there was growth too in Scotland and Wales, but in Northern Ireland changes to funding entitlements for older workers have reduced the total numbers;
- Apprenticeship growth in engineering-related sectors and ICT is proportionally strongest in Higher Apprenticeships – the profile is shifting towards higher levels, as desired, and much more so than in many other sectors, where level 2 numbers continue to dominate;
- The age of starters is decreasing for engineering, with 41% of starters in England aged under 19, in contrast to the picture overall, where around half are over 25 years of age;
- Very few (7%) engineering-related apprentices are female, and in some areas and sectors, only 3%;
- A quarter of a million workplaces now offer apprenticeships, a rise of nearly 5% in a year and 50% over five years;
- Productivity gains are shown to be highest for young apprentices, and the success rate amongst engineering-related apprenticeships has risen to over 70%.

Degree Apprenticeships

Degree Apprenticeships are obtaining a great deal of scrutiny and the first schemes have launched including in manufacturing and engineering sectors. They offer great promise as an alternative to traditional campus-based higher education, allowing students to obtain a university degree without paying tuition fees and while earning a salary as an employee. The expected introduction of the Apprenticeship Levy may catalyse the scale of their development.

6.1 An evolving apprenticeships and further education landscape

6.1.1 Apprenticeships

All skills and training policy is devolved to the separate nations in the UK. As a result, England, Scotland, Wales and Northern Ireland all have their own apprenticeships and skills policies and programmes that may differ in terms of levels, funding, aims and challenges.

Although apprenticeships have been part of the employment landscape for centuries, the number in the UK declined in the 1970s and 1980s. They have regained favour in the last decade, however, and are currently a major focus for educational and industrial policy across the UK. This is for their potential to increase the level of skills in the workforce and help to satisfy industry's needs, and to address youth unemployment by providing an attractive vocational pathway for young people that can promote greater social mobility.[6.1, 6.2] Policy-wise, they are seen as something of a counterbalance to recent policy emphasis on higher education. Research has shown that the employment rate of apprentices is much higher than that of young people without qualifications,[6.3] and also that apprentices earn more over their working life than those who have A levels as their highest qualification.[6.4]

Since 2010, the government has made clear that apprenticeships would be prioritised as the primary educational route, including through the abolition of the more generic 'Train to Gain' programme and with funding redistributed to apprenticeship starts. The current government has committed to increasing the number of apprenticeship starts to three million by 2020, believing that every £1 invested in apprenticeships at levels 2 and 3 results in a return of £26-28.[6.5] To fund this, and at the same time improve the quality of provision, in 2015 it announced a new 'Apprenticeship Levy' on employers.[6.6] It has since published

6.1 BIS: *The contribution of FE and skills to social mobility*, October 2015. https://www.gov.uk/government/publications/social-mobility-contribution-of-further-education-and-skills **6.2** Dr Philip Kirby: *Levels of success – the potential of UK apprenticeships* (Sutton Trust), October 2015. http://www.suttontrust.com/researcharchive/levels-of-success/ **6.3** Luke Raikes: *Learner drivers: local authorities and apprenticeships* (Institute for Public Policy Research), June 2015. http://www.ippr.org/publications/learner-drivers-local-authorities-and-apprenticeships **6.4** Social Mobility and Child Poverty Commission (blog). 13 November 2014 **6.5** DfE & BIS: *English Apprenticeships: Our 2020 vision*, 2016. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/482754/BIS-15-604-english-apprenticeships-our-2020-vision.pdf **6.6** HM Treasury: Summer Budget 2015, July 2015. https://www.gov.uk/government/topical-events/budget-july-2015. https://www.gov.uk/government/topical-events/budget-july-2015 proposals for employers to pay a levy equivalent to 0.5% of their salary bill from April 2017, exempting employers whose salary costs are below £3 million. The proposals suggest enhanced funding for STEM apprenticeships, and extra support for small companies and those that take on young apprentices (16- to 18-year-olds) and care leavers.[6.7] Most recently, the Department for Education has announced that there will be a Technical Education Bill to take forward some elements of this agenda. Apprenticeships is a fast-moving area and policy and practice are evolving all the time.

The National Apprenticeship Service (NAS) has been responsible for overseeing apprenticeships in England since 2009. However, the government has committed to a series of reforms, including the launch of the Institute for Apprenticeships in spring 2017, to regulate quality through its approval of apprenticeship standards. In addition, a Digital Apprenticeship Service will support employers to find education partners and act as a portal for vacancies.

Current apprenticeship frameworks are being replaced by these new apprenticeship standards, led by sector-based employer groups called Trailblazers. In doing this, it is hoped that the content of new apprenticeships will be oriented towards the needs of industry and provide apprentices with high-quality training that is very relevant to their work. Engineering employers have been closely involved in many of the Trailblazers projects.

In order to increase the quality and rigour of apprenticeships, the government has stated that the core principles underlying an apprenticeship need to be for it to comprise a job in a skilled occupation and involve a minimum of a year's training (including at least 20% off-the-job learning). It must also include the development of transferable skills, as well as English and maths, all of which will be demonstrated by achievement of the apprenticeship standard through a final assessment.[6.8] Two recent reports have commented that the quality of apprenticeships needs to be increased in order to make the most of this policy focus and investment,[6.9] including one by Policy Exchange which suggests that without tightening of practice £500 million of public money could be spent every year from 2020 supporting young people and adults to undertake new apprenticeship standards which are not aligned with the traditional definition of an apprenticeship.[6.10]

6.1.2 Higher level apprenticeships

Recent apprenticeship frameworks (and new apprenticeship standards) have different levels, from Intermediate Apprenticeships at level 2 (roughly equivalent to 5 GCSE passes) upwards (Figure 6.1). Advanced Apprenticeships are level 3 frameworks, which broadly equate to 2 A level passes, while Higher Apprenticeships are at level 4, although these constitute a small fraction numerically of all apprenticeships. Degree Apprenticeships were announced as a concept in late 2014 at levels 6 and 7 – equivalent to a first or master's degree respectively.

The increasing focus on apprenticeships at higher levels has resulted from concerns that much of the initial growth in apprenticeship activity was in low-cost areas and typically leading to level 2 qualifications. Much of the growth came from existing company employees whose training was converted into apprenticeship programmes at level 2 or 3, rather than newly employed workers. This was reflected in the age profile of apprenticeships: in England, at least 43% of new apprentices were over the age of 25 in 2014/15 and only 25% were under 19.[6.12] Engineering institutions have also expressed concern that much of the growth in numbers was in retail, healthcare and business generally. The greatest need for apprenticeships in STEM and engineering sectors is thought to be at level 3 and upwards, where there are concerns about current and future skills shortages. Apprentices at these levels are considerably more costly for the employer: a level 3 apprenticeship could cost an employer as much as £40,000, a cost that could take a further three years of employment to recoup.[6.13] Due to this strategic importance, the focus of this chapter will be on level 3 and higher levels of apprenticeship where possible.

There is currently particular interest in the development of Degree Apprenticeships (see page 97). Many of the first new Degree Apprenticeship Standards that have been developed and approved are engineering-focused, including aerospace, automotive, construction, digital industries, electronic systems, and nuclear. Due to the integrated degree qualification, Degree Apprenticeships are expected to prove highly attractive to students who may be concerned about the debt inherent in a student loan that is likely to fund a university degree. They are also attractive to HE institutions in offering diversification in their offer and potentially assisting in their efforts to widen participation. They will also boost university/employer relationships. As substantial employers themselves, HE institutions will be required to pay the apprenticeship levy and this may prove a further incentive for them to develop Degree Apprenticeships.

Figure 6.1: Apprenticeship types and levels[6.11]

Apprenticeship level	Equivalent education level	Apprenticeship type
Level 7 Level 6	Master's degree Bachelor's degree	Degree Apprenticeships
Level 5 Level 4	Higher Education Certificate (CertHE) or Diploma (DipHE), Higher National Certificate (HNC), Higher National Diploma (HND), Foundation degree	Higher Apprenticeships
Level 3	2 A Level passes	Advanced Apprenticeships
Level 2	5 GCSE passes at grades A* to C	Intermediate Apprenticeships

Source: NCUB

6.7 DfE: *Apprenticeship funding – proposals for apprenticeship funding in England from May 2017*, August 2016. https://www.gov.uk/government/publications/apprenticeship-funding-from-may-2017
6.8 DfE & BIS: *English Apprenticeships: Our 2020 vision*, 2016. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/482754/BIS-15-604-english-apprenticeships-our-2020-vision.pdf **6.9** IPPR: *England's apprenticeships: Assessing the new system*, August 2016. http://www.ippr.org/publications/englands-apprenticeships-assessing-the-new-system **6.10** Policy Exchange: *The Skills We Need, And Why We Don't Have Them. How Apprenticeships should be reformed to make the UK compete on the global stage*, October 2016. https://policyexchange.org.uk/wp-content/uploads/2016/11/Apprenticeships.pdf **6.11** Reproduced with permission from National Centre for Universities and Business: *Degree Apprenticeships Briefing*, April 2016. http://www.ncub.co.uk/reports/degree-apprenticeships-briefing.html **6.12** House of Commons: *Apprenticeship statistics for England 1996-2015*, November 2015. http://researchbriefings.parliament.uk/ResearchBriefing/Summary/SN06113 **6.13** Lynn Gamblin and Terence Hogarth: *Employer investment in intermediate STEM skills: How employers manage the investment risk associated with apprenticeships* (Institute for Employment Research, Gatsby Foundation), February 2016. http://www.gatsby.org.uk/uploads/education/gatsby-employer-investment-apprenticeships.pdf

Degree Apprenticeships

This summary is based on the National Centre for Universities and Business (NCUB) *Degree Apprenticeships Briefing*.[1.14]

A Degree Apprenticeship combines aspects of both higher and vocational education and is designed to test both occupational competence and academic learning. This can be through a fully-integrated degree programme (co-designed by employers and HE institutions) or a degree plus a separate test of professional competence. A core part of a Degree Apprenticeship is a bachelor's (Apprenticeship level 6) or master's (level 7) degree qualification. It is the inclusion of the integrated degree qualification that makes a Degree Apprenticeship different from a Higher Apprenticeship at an equivalent level.

The apprentice is paid throughout the programme, including periods when they are training, or they can receive a training salary. Training can be delivered through 'day release' or 'block release' type approaches, depending on the programme and employer's requirements. The training may also include work-based, distance learning or/and blended online/face-to-face learning. There is a standard (20+ days) holiday entitlement and the apprentice holds all the employment rights of any other employee.

Degree Apprenticeships are generally structured as a mix of core compulsory and elective modules, as well as work-based projects incorporated by the employer. The elective modules enable the employer to tailor this aspect of the training and learning to meet the needs of their business.

The duration of a Degree Apprenticeship can vary but from a minimum length of 12 months. Many are expected to last for up to four years. (There is no maximum duration).

A Degree Apprenticeship will be awarded by the HE institution upon successful completion of the programme – which either comprises a degree course where academic skills and on-the-job learning are wholly incorporated and tested or an existing degree course combined with an end of programme assessment of academic and occupational proficiency. The degree is of equivalent standard to that achieved through a full-time undergraduate programme. The HE institution may also partner with other providers such as FE colleges or private training providers to ensure that all aspects of the learning requirements are delivered well.

On the funding side, where an apprenticeship fulfils the requirements of an Apprenticeship Standard, the course fees and training costs are currently funded two thirds by the government and one third by the employer, so the apprentice can earn a university degree without paying any tuition fees. The maximum government contribution is £18,000, although there are additional incentive payments for small businesses to participate, and for successful completion, and/or for recruiting a 16- to 18-year-old as an apprentice.

A Degree Apprentice is first and foremost an employee of the employing organisation, with an employment contract and, as such, the employer will usually be responsible for their recruitment. However, all parties involved will need to verify that the applicant meets their eligibility and entry criteria, so recruitment may be jointly run between a university and its collaborating employers. The apprentice can be a new recruit or an existing employee.

The entry requirements will depend on the sector, including prior skills acquired and the potential to gain those required. The apprentice must have the right to work and reside in the UK, and be employed and paid for at least 30 hours a week (including non-workplace training). Pay must be at least at the appropriate national minimum apprenticeship wage level. As Degree Apprenticeships are associated with senior occupational job roles, higher market wage rates may be applied, at the employer's discretion. All employers will be able to access government funding for apprenticeships irrespective of whether they have paid into the proposed Apprenticeship Levy or not.

In September 2015, the first university/business co-developed Degree Apprenticeship programmes were launched, in the digital, automotive engineering, banking and construction fields. More than 70 universities have registered to deliver Higher Apprenticeships and/or Degree Apprenticeships. The Higher Education Funding Council for England (HEFCE) is currently funding a range of universities to develop new provision through its Degree Apprenticeship Development Fund.

6.1.3 Further education at a crossroads

Further education has traditionally been a highly diverse sector of education in the UK, meeting the needs of a wide variety of learners and providing them with an equally wide range of qualifications, including technical and vocational academic qualifications. UK further education (FE) comprises around 3.8 million learners, making it even larger than higher education in terms of total number studying. This could be accounted for by its wider age range: FE includes study programmes for 16- to 19-year olds, but around 2.9 million FE learners are adults, many of whom are studying part-time, and this is a key feature of the 'skills' landscape of FE.

The main drivers in educational and government policy in the UK over the last two decades have tended to focus on young people in schools and also the expansion of higher education, into which higher proportions of young people have been encouraged to progress. In contrast, the FE sector has struggled financially: government skills spending per person aged 20-60 in England and Wales halved between 2009/10 and 2015/16,[6.15] and nearly half of England's FE colleges are now in deficit, contributing to the sector's overall decline in financial health.[6.16] The number of FE colleges has continued to decline gradually, with a drop of nearly 8% between 2013 and 2016 (Table 6.1). However, a number of these will have been mergers, so the effect on engineering-related education and training provision is not transparent. The greatest declines by proportion have been of FE colleges in Scotland and general FE colleges in England, each of which have lost ten colleges in the past three years.

The government has stated that the sector has also grown highly complex, with a wide range of different qualification schemes and learning pathways with very different aims, including delivery of higher education programmes. It believes the notion of 'further education' as a generic term for all non-university, post-school education is outdated, and 'represents a dangerous conflation of two very different types of training'.[6.18]

At the same time, FE colleges tend to be the educational environment for apprenticeships, upon which recent governments are placing great emphasis as a means to improve historically low levels of skills and respond to industry's needs for higher skills and productivity. For this reason, this chapter covers both apprenticeships and further education. This also partly reflects the growing evidence that the government is seeking to move towards

6.14 National Centre for Universities and Business: *Degree Apprenticeships Briefing*, April 2016. http://www.ncub.co.uk/reports/degree-apprenticeships-briefing.html **6.15** DfE: *Review of vocational education, 2011 The Wolf Report: recommendations final progress report*, February 2015. https://www.gov.uk/government/publications/wolf-recommendations-progress-report **6.16** NAO: *Overseeing financial sustainability in the further education sector*, July 2015. https://www.nao.org.uk/report/oversight-of-financial-sustainability-in-the-further-education-sector/ **6.18** p35. BIS: *A dual mandate for adult vocational education, a consultation paper*, March 2015. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/427342/bis-15-145-A-dual-mandate-for-adult-vocational-education.pdf

Table 6.1: Further education colleges by nation (2013-2016) – UK[6.17]

		2013	2014	2015	2016
England		341	339	335	325
	General FE colleges	219	218	216	209
	Sixth form colleges	94	93	93	90
	Land-based colleges	15	15	14	14
	Art, design and performing arts colleges	3	3	2	2
	Specialist designated colleges	10	10	10	10
Scotland		36	30	26	26
Wales		19	16	15	14
Northern Ireland		6	6	6	6
UK total		402	391	382	371

Source: Association of Colleges

a position where the two dominant progression routes for young people are either through an apprenticeship or higher education.

So there is a sense that FE in the UK is at a crossroads, although it is well placed to deliver much of the higher professional and technical education that many projections suggest the UK economy needs, particularly in the engineering sector.[6.19]

In the meantime, the government's Post-16 Skills Plan[6.20] builds on the recommendations of the Report of the Independent Panel on Technical Education, led by Lord Sainsbury.[6.21] Highlights of the plan include the following:

- Steps to redress the gender imbalance in STEM education and careers;
- Proposals to introduce Institutes of Technology (IoTs) to provide technical education in STEM subjects at levels 3, 4 and 5, which are likely to build on infrastructure and good practice that already exists;
- Recognition of the role of government in targeting specific parts of the engineering sector to provide a pipeline of sufficiently skilled workers for a range of shortage occupations.

It suggests that a more coherent technical education pathway would be beneficial to develop the technical skills and knowledge needed for people to enter such occupations. It proposes that a greatly simplified landscape of skills pathways would be beneficial, using two modes of learning: employer-based (apprenticeships, with part-time learning) and college-based (ideally combined with structured experiences of work). Qualifications achieved through 15 technical educational routes could potentially replace as many as 20,000 different qualifications. The pathways would lead to a range of skilled occupations where there is a significant requirement for technical knowledge and/or practical skills, but the concept runs some risk of reinforcing the perceived divide between academic and vocational education. The plan also proposes a Technical Baccalaureate (TechBacc), a performance measure that includes an approved level 3 tech level qualification, a level 3 maths qualification and an extended project.

Traineeships were introduced in August 2013 as a means of preparing young people for apprenticeships or work. These programmes, lasting six weeks to six months, include work preparation training, English and mathematics and a placement. They are targeted at 16- to 19-year olds who are not currently in a job and have little work experience but seek a vocational path into employment, and whom the providers and employers believe have a reasonable chance of being ready for employment or an apprenticeship within six months of engaging in the traineeship.[6.22] Another initiative, outside the FE sector, with potential to impact on the uptake and quality of STEM technical education, is the growth of university technical colleges (UTCs), which are described in Chapter 5.

Finally, the government has also announced the development of a series of national colleges for key growth sectors, including high-speed rail, nuclear, onshore oil and gas, digital skills, and the creative and cultural industries. These will focus on delivering technical skills at levels 4 to 6, with the first colleges to be open by 2017.

In terms of qualifications, in September 2015, Ofqual launched the Regulated Qualifications Framework (RQF), which, "will provide a single, simple system for cataloguing all qualifications regulated by Ofqual."[6.23] Ofqual and the awarding bodies are currently removing references to the old frameworks (the Qualification and Credit Framework, or QCF, and the National Qualifications Framework, NQF, within which sat NVQs and SVQs).

In the devolved nations, the Scottish Credit and Qualifications Framework is specific to Scotland but can be cross-referenced to the European Qualifications Framework (EQF),[6.24] as can the Credit & Qualifications Framework for Wales (CQFW) which covers all qualifications accredited for use in Wales. Since May 2016, CCEA regulates vocational qualifications in Northern Ireland.

6.17 AoC: *Key further education statistics*. https://www.aoc.co.uk/about-colleges/research-and-stats/key-further-education-statistics **6.19** Policy Exchange: *Higher, further, faster, more. Improving higher level professional and technical education*, 2015. https://policyexchange.org.uk/publication/higher-further-faster-more-improving-higher-level-professional-and-technical-education/ **6.20** BIS & DfE, Post-16 Skills Plan, 2016. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/536043/Post-16_Skills_Plan.pdf **6.21** DfE: *Report of the Independent Panel on Technical Education*, 2016. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/536046/Report_of_the_Independent_Panel_on_Technical_Education.pdf **6.22** SFA: *Traineeships* (web page), 22 May 2015. https://www.gov.uk/government/collections/traineeships-programme **6.23** Ofqual: *Ofqual to introduce new Regulated Qualifications Framework* (web page) 2016: https://www.gov.uk/government/news/ofqual-to-introduce-new-regulated-qualifications-framework **6.24** Scottish Credit and Qualifications Framework: *Qualifications can cross boundaries – A guide to comparing qualifications in the UK and Ireland*, 2014. http://scqf.org.uk/wp-content/uploads/2014/11/Qualifications-Can-Cross-Boundaries-2014-for-web.pdf

Back to Contents

6.2 Participation in apprenticeships in England

6.2.1 Apprenticeship starts by sector

The total number of apprenticeships increased by 15% between 2013/14 and 2014/15 although, at just under half a million starts, it remained below the peak of 520,600 in 2011/12 (Table 6.2). Starts in engineering-related Sector Subject Areas also increased by 15% between 2013/14 and 2014/15, reaching 108,000 – the highest number in the last ten years. This growth resulted in engineering-related Sector Subject Area apprenticeship starts rising very slightly as a proportion of all apprenticeship starts, to nearly 22%. Over both the previous year and the last ten years, the greatest proportional increase in apprenticeship starts was in information and communication technology, reaching over 15,600 in 2014/15. However, the greatest number remained in engineering and manufacturing technologies (74,000 in 2014/15).

Table 6.3 shows the number of apprenticeship starts by English region and Sector Subject Area. The highest number of apprenticeship starts was in the North West of England, with 16% of all apprenticeship starts and 14% of those in engineering-related Sector Subject Areas in 2014/15. There was a distinct concentration of engineering-related subject area apprenticeships in the North West, the West Midlands and South East of England. This pattern largely replicates the position seen in 2013/14. The relatively lower apparent concentration in London reflects the dominance of service sector enterprises and employment in the capital. More analysis of the employers that participate in apprenticeships is shown in section 6.2.4.

By level (Table 6.4), the greatest proportional growth across all Sector Subject Areas has been in Higher Apprenticeship starts. These more than doubled between 2013/14 and 2014/15 to 20,000, albeit from a low base. There were nearly ten times more (ie nearly 200,000) Advanced Apprenticeship starts in 2014/15, an increase of just over a quarter on the previous year. In contrast, the growth in starts in 2014/15 at Intermediate Apprenticeship level was a more modest 4% on the previous year (although this still constituted an increase of approximately 100,000 starts). Overall, the proportion of all apprenticeship starts at level 3 or above was 40%, compared with 34% in 2013/14.

Table 6.2: Apprenticeship programme starts by Sector Subject Area (2004/05-2014/15) – England[6.25, 6.26, 6.27]

	2010/11	2011/12	2012/13	2013/14	2014/15	Change over 1 year	Change over 5 years
Construction, planning and the built environment	22,420	13,920	13,730	15,890	18,290	15.1%	-18.4%
Engineering and manufacturing technologies	54,640	69,730	66,410	64,830	74,060	14.2%	35.5%
Information and communication technology	19,520	18,520	14,120	13,060	15,660	19.9%	-19.8%
Subtotal – all engineering related sector subject areas	96,580	102,170	94,260	93,780	108,010	15.2%	11.8%
All engineering related sector subject areas as a proportion of all sector subject areas	21.1%	19.6%	18.5%	21.3%	21.6%	1.5%	2.3%
Science and mathematics	10	370	320	360	380	5.6%	3700.0%
All sector subject areas	457,200	520,600	510,200	440,400	499,900	13.5%	9.3%

Source: SFA

Table 6.3: Apprenticeship programme starts by English region and sector (2014/15) – England[6.28]

		English region									
		North East	North West	Yorkshire and The Humber	East Midlands	West Midlands	East of England	London	South East	South West	England total
Construction, planning and the built environment	Number	1,630	3,070	2,570	1,730	1,810	1,620	1,260	2,100	2,370	**18,140**
	Percentage of total	9.0%	16.9%	14.2%	9.5%	10.0%	8.9%	6.9%	11.6%	13.1%	
Engineering and manufacturing technologies	Number	5,270	10,020	8,680	7,340	11,440	6,770	4,420	10,380	8,620	**72,930**
	Percentage of total	7.2%	13.7%	11.9%	10.1%	15.7%	9.3%	6.1%	14.2%	11.8%	
Information and communication technology	Number	920	2,040	1,160	1,190	1,700	1,200	1,940	2,620	2,750	**15,510**
	Percentage of total	5.9%	13.2%	7.5%	7.7%	11.0%	7.7%	12.5%	16.9%	17.7%	
Sub-total all engineering related sector subject areas	Number	7,820	15,130	12,410	10,260	14,950	9,590	7,620	15,100	13,740	**106,580**
	Percentage of total	7.3%	14.2%	11.6%	9.6%	14.0%	9.0%	7.1%	14.2%	12.9%	
Science and mathematics	Number	40	110	60	30	20	40	10	40	20	**380**
	Percentage of total	10.8%	29.7%	16.2%	8.1%	5.4%	10.8%	2.7%	10.8%	5.4%	
All sector subject areas	Number	35,220	79,310	62,550	48,060	61,240	45,790	45,550	65,030	51,480	**494,200**
	Percentage of total	7.1%	16.0%	12.7%	9.7%	12.4%	9.3%	9.2%	13.2%	10.4%	

Source: SFA

6.25 Volumes are rounded to the nearest ten. 6.26 In this table, full-year numbers are a count of the number of starts at any point during the year. Learners starting more than one apprenticeship will appear more than once. 6.27 Figures for 2011/12 onwards are not directly comparable to earlier years as a Single Individualised Learner Record (ILR) data collection system has been introduced. Small technical changes have been made in the way learners from more than one provision type are counted, leading to a removal of duplicate learners and a reduction in overall learner numbers of approximately 2%. 6.28 See notes to Table 6.2

The pattern for apprenticeship starts in all engineering-related Sector Subject Areas was similar, with 63,000 starts at intermediate level (up 12% on previous year) and 43,000 at advanced level (up nearly 18%). There was a 77% rise in starts at higher level, but the total number reached was only 1,770 starts. However, this demonstrates that there was growth in the engineering-related sectors at all levels, and the growth over the last ten years has been substantial (77%), although not to the same extent as for apprenticeships overall. In the engineering-related Sector Subject Areas, 41% of apprenticeship starts were at level 3 or above, slightly higher than overall (40%).

The numbers of starts at each level for each for individual Sector Subject Areas related to engineering increased between 2013/14 and 2014/15. (The exception at intermediate level was information and communication technology, which decreased by nearly 2%.) Although a numerically smaller sector for starts overall, information and communication technology had more advanced level starts than intermediate ones in 2014/15. This reflects that 71% of starts were at or above level 3, compared with 40% in engineering and manufacturing and 21% in construction.

Table 6.4: Apprenticeship programme starts by Sector Subject Area and level (2004/05-2014/15) – England[6.29]

		2010/11	2011/12	2012/13	2013/14	2014/15	Change over 1 year	Change over 10 years
Construction, planning and the built environment	Intermediate apprenticeship	16,020	10,850	10,470	12,600	14,390	14.2%	-5.5%
	Advanced apprenticeship	6,400	3,080	3,210	3,210	3,800	18.4%	-35.3%
	Higher apprenticeship	-	-	60	70	100	42.9%	-
	All apprenticeships	22,420	13,920	13,730	15,890	18,290	15.1%	-13.3%
	Percentage level 3+	28.5%	22.1%	23.8%	20.6%	21.3%	-0.3%	-6.5%
Engineering and manufacturing technologies	Intermediate apprenticeship	32,220	45,570	38,720	39,110	44,350	13.4%	128.4%
	Advanced apprenticeship	22,340	24,040	27,470	25,450	29,290	15.1%	86.9%
	Higher apprenticeship	80	120	220	270	420	55.6%	-
	All apprenticeships	54,640	69,730	66,410	64,830	74,060	14.2%	111.1%
	Percentage level 3+	41.0%	34.6%	41.7%	39.7%	40.1%	0.4%	-4.6%
Information and communication technology	Intermediate apprenticeship	8,640	8,430	5,440	4,590	4,510	-1.7%	36.3%
	Advanced apprenticeship	10,830	9,910	8,270	7,820	9,900	26.6%	211.3%
	Higher apprenticeship	60	190	420	660	1,250	89.4%	-
	All apprenticeships	19,520	18,520	14,120	13,060	15,660	19.9%	141.3%
	Percentage level 3+	55.8%	54.5%	61.5%	64.9%	71.2%	6.3%	22.2%
Sub-total all engineering related sector subject areas	Intermediate apprenticeship	56,880	64,850	54,630	46,910	63,250	12.3%	66.7%
	Advanced apprenticeship	39,570	37,030	38,950	33,340	42,990	17.8%	73.9%
	Higher apprenticeship	140	310	700	1,000	1,770	77.0%	-
	All apprenticeships	96,580	102,170	94,260	93,780	108,010	15.2%	72.3%
	Percentage level 3+	41.1%	36.5%	42.1%	36.6%	41.4%	0.4%	2.0%
All engineering related sector subject areas as a proprotion of all sector subject areas	Intermediate apprenticeship	18.9%	19.7%	18.7%	16.4%	21.2%	1.5%	-9.7%
	Advanced apprenticeship	25.7%	19.7%	18.8%	23.0%	23.6%	-1.6%	-23.8%
	Higher apprenticeship	6.4%	8.4%	7.1%	10.9%	8.9%	-2.0%	-
	All apprenticeships	21.1%	19.6%	18.5%	21.3%	21.6%	0.3%	-14.2%
Science and mathematics	Intermediate apprenticeship	-	90	70	80	70	-12.5%	-
	Advanced apprenticeship	10	280	250	280	270	-3.6%	-
	Higher apprenticeship	0	-	-	-	50		-
	All apprenticeships	10	370	250	360	380	5.6%	-
	Percentage level 3+	100.0%	75.7%	100.0%	77.8%	84.2%	6.4%	-
All sector subject areas	Intermediate apprenticeship	301,100	329,000	292,800	286,500	298,300	4.1%	142.9%
	Advanced apprenticeship	153,900	187,900	207,700	144,700	181,800	25.6%	248.9%
	Higher apprenticeship	2,200	3,700	9,800	9,200	19,800	115.2%	-
	All apprenticeships	457,200	520,600	510,200	440,400	499,900	13.5%	185.7%
	Percentage level 3+	34.1%	36.8%	42.6%	34.9%	40.3%	5.4%	10.5%

Source: SFA

6.29 See notes to Table 6.2

6.2.2 Age of apprenticeship starters

The age profile of apprenticeship starters is different for engineering-related Sector Subject Areas and apprenticeships overall. In 2014/15, the largest proportion of apprenticeship starters across all Sector Subject Areas combined (47%) were 25 or older, while 28% were under 19 (Table 6.5). In contrast, across all engineering-related Sector Subject Areas, over 40% of those starting an apprenticeship were under 19 and only 25% were 25 or over.

Figure 6.2 summarises the age profile of apprenticeship starters over the last five years for the key engineering-related Sector Subject Areas. Broadly, these show that a significantly higher proportion of construction-related apprentices were younger than those in engineering and manufacturing or information and communications technology: over half were under 19. The proportion in construction-related areas has remained broadly consistent over the five years, whereas in engineering and manufacturing, there has been a decrease in both young (under 19) and older (25 and over) starters, with a growing proportion aged 19-24. The latter pattern is to a lesser extent also seen in the information and communications technology Sector Subject Area. Over 90% of all apprenticeships have had a duration of twelve months or longer since 2012/13, and the proportion for young starters (under 19) reached 98% in 2013/14,[6.31] reflecting the firm policy intention for all apprenticeships to be at least a year in length.

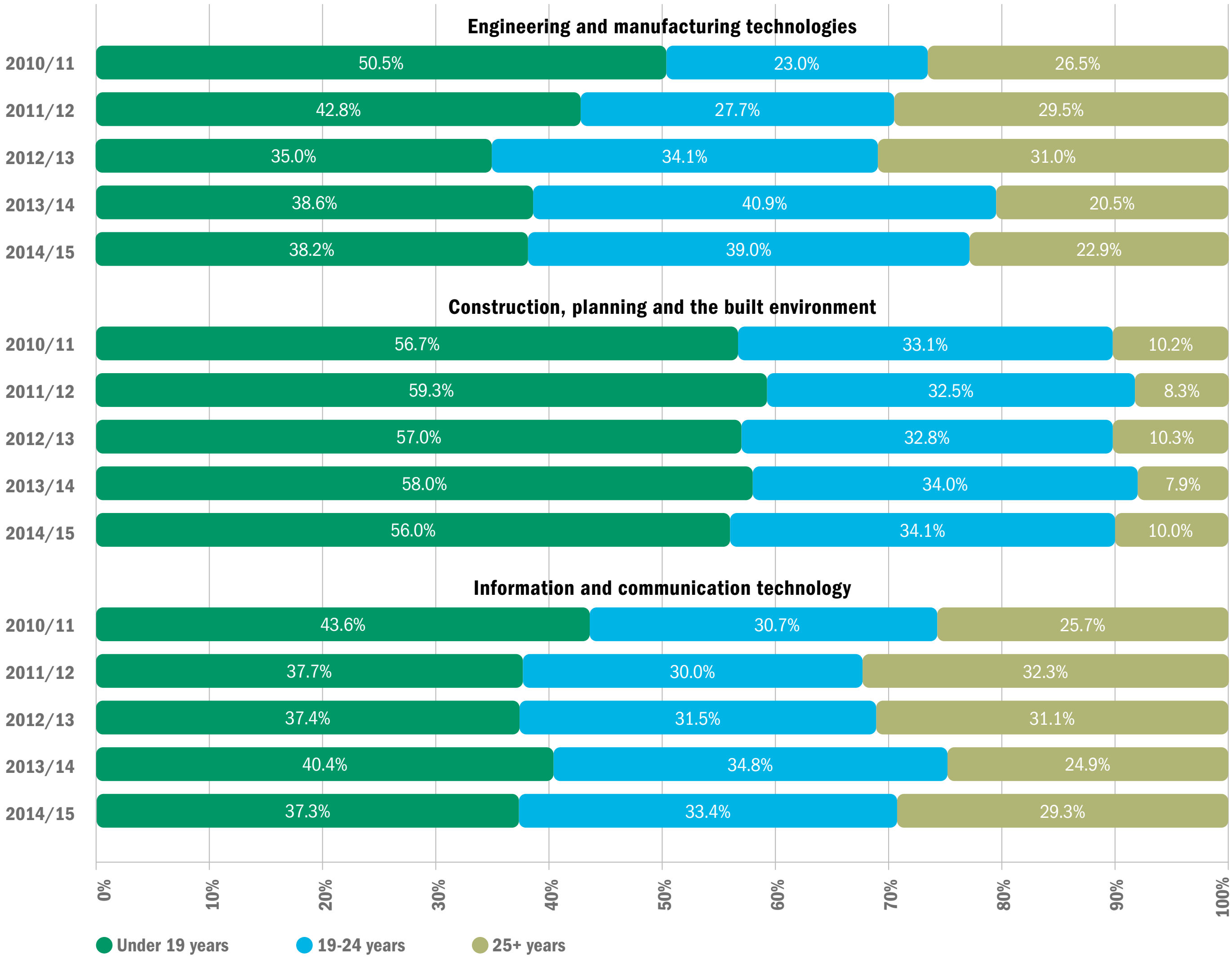
Table 6.5: Apprenticeship programme starts by Sector Subject Area, level and age (2014/15) – England[6.30]

	Age	Intermediate level apprenticeship	Advanced level apprenticeship	Higher apprenticeship	All apprenticeships
Construction, planning and the built environment	Under 19	8,690	1,530	20	10,240
	19-24	4,330	1,860	60	6,240
	25+	1,380	410	20	1,820
	All ages	14,390	3,800	100	18,290
	Percentage of all apprentices aged under 19	60.4%	40.3%	20.0%	56.0%
Engineering and manufacturing technologies	Under 19	15,160	12,380	110	27,640
	19-24	11,990	12,430	270	24,700
	25+	17,200	4,480	40	21,720
	All ages	44,350	29,290	420	74,060
	Percentage of all apprentices aged under 19	34.2%	42.3%	26.2%	37.3%
Information and communication technology	Under 19	1,030	4,520	430	5,980
	19-24	1,510	3,830	750	6,100
	25+	1,970	1,550	70	3,590
	All ages	4,510	9,900	1,250	15,660
	Percentage of all apprentices aged under 19	22.8%	45.7%	34.4%	38.2%
Sub-total all engineering related sector subject areas	Under 19	24,880	18,430	560	43,860
	19-24	17,830	18,120	1,080	37,040
	25+	20,550	6,440	130	27,130
	All ages	63,250	42,990	1,770	108,010
	Percentage of all apprentices aged under 19	39.3%	42.9%	31.6%	40.6%
Science and mathematics	Under 19	20	140	20	180
	19-24	30	110	20	160
	25+	20	20	-	40
	All ages	70	270	40	380
	Percentage of all apprentices aged under 19	28.6%	51.9%	50.0%	47.4%
All sector subject areas	Under 19	85,600	39,100	1,100	125,900
	19-24	93,600	62,400	4,200	160,200
	25+	119,100	80,300	14,400	213,900
	All ages	298,300	181,800	19,800	449,900
	Percentage of all apprentices aged under 19	28.7%	21.5%	5.6%	28.0%

Source: SFA

6.30 Age is calculated based on age at start of the programme rather than based on 31 August. **6.31** EngineeringUK: *The state of engineering* 2016, January 2016. http://www.engineeringuk.com/Research/

Figure 6.2: Apprenticeship programme starts in key engineering-related Sector Subject Areas by age (2010/11-2014/15) – England



Source: SFA

6.2.3 Apprenticeship achievements

Table 6.6 shows the number of apprentice achievements by Sector Subject Area over the last five years. Overall, for all subject areas, the total number of achievements increased by 2% between 2013/14 and 2014/15 to a total of almost 261,000. However, the percentage of achievements at level 3 or above fell by 2.5 percentage points. This is part of an overall rise of 30% over the past five years, including an increase of 4% in those at level 3 or above.

Achievements in engineering-related subject areas rose by almost 10% compared with 2013/14, reversing a recent decline and bringing the increase over five years to 4%. The proportion at level 3 or above rose slightly, but over four years this proportion has fallen 6 percentage points, although it is still slightly above the proportion amongst all apprenticeships. This reflects the number of achievements in Advanced Apprenticeships falling over the period, while achievements at intermediate level have steadily increased. Higher Apprenticeship achievements have multiplied but remain a small fraction of the overall numbers.

Achievement numbers have increased consistently at all levels in engineering and manufacturing technologies, especially at intermediate level which is nearly 60% higher than in 2010/11. This growth accounts for the increase seen across all engineering-related Sector Subject Areas and masks some declines in achievements in apprenticeships in construction, planning and the built environment and a mixed picture in ICT over the same period.

Table 6.6: Apprenticeship achievements by Sector Subject Area and level (2010/11-2014/15) – England[6.32]

		2010/11	2011/12	2012/13	2013/14	2014/15	Change over 1 year	Change over 5 years
Construction, planning and the built environment	Intermediate apprenticeship	9,110	8,270	6,510	5,980	6,380	6.7%	-30.0%
	Advanced apprenticeship	5,130	4,340	2,560	2,030	2,070	2.0%	-59.6%
	Higher apprenticeship	-	-	-	10	20	100.0%	-
	All apprenticeships	14,240	12,600	9,060	8,030	8,470	5.5%	-40.5%
	Percentage level 3+	36.0%	34.4%	28.3%	25.4%	24.7%	-0.7%p	-11.3%p
Engineering and manufacturing technologies	Intermediate apprenticeship	15,830	20,130	23,790	22,740	24,920	9.6%	57.4%
	Advanced apprenticeship	15,360	14,400	13,370	14,470	16,020	10.7%	4.3%
	Higher apprenticeship	-	20	20	30	90	200.0%	-
	All apprenticeships	31,190	34,550	37,180	37,240	41,040	10.2%	31.6%
	Percentage level 3+	49.2%	41.7%	36.0%	38.9%	39.3%	0.4%p	-9.9%p
Information and communication technology	Intermediate apprenticeship	4,130	4,680	3,400	3,100	2,740	-11.6%	-33.7%
	Advanced apprenticeship	6,320	4,680	4,130	4,640	5,690	22.6%	-10.0%
	Higher apprenticeship	60	40	50	100	390	290.0%	-
	All apprenticeships	10,510	9,400	7,580	7,840	8,820	12.5%	-16.1%
	Percentage level 3+	60.7%	50.2%	55.1%	60.5%	68.9%	8.4%p	8.2%p
Sub-total all engineering related sector subject areas	Intermediate apprenticeship	29,070	33,080	33,700	31,820	34,040	7.0%	17.1%
	Advanced apprenticeship	26,810	23,420	20,060	21,140	23,780	12.5%	-11.3%
	Higher apprenticeship	60	60	70	140	500	257.1%	-
	All apprenticeships	55,940	56,550	53,820	53,110	58,330	9.8%	4.3%
	Percentage level 3+	48.0%	41.5%	37.4%	40.1%	41.6%	1.5%p	-6.4%p
Science and mathematics	Intermediate apprenticeship	-	-	50	30	40	33.3%	-
	Advanced apprenticeship	-	10	60	110	170	54.5%	-
	Higher apprenticeship	0	0	-	-	-	-	-
	All apprenticeships	-	10	120	140	210	50.0%	-
	Percentage level 3+	-	100.0%	50.0%	78.6%	81.0%	2.4%p	-
All sector subject areas	Intermediate apprenticeship	131,700	172,400	156,300	150,900	160,300	6.2%	21.7%
	Advanced apprenticeship	67,500	84,700	95,000	102,200	96,200	-5.9%	42.5%
	Higher apprenticeship	1,000	1,200	1,600	2,700	4,300	59.3%	-
	All apprenticeships	200,300	258,400	252,900	255,800	260,900	2.0%	30.3%
	Percentage level 3+	34.2%	33.2%	38.2%	41.0%	38.5%	-2.5%p	4.3%p

Source: SFA

6.32 Figures for Sector Subject Area in 2012/13 were recorded on a different basis to earlier years due to a change in the way apprenticeship frameworks were allocated to Sector Subject Areas.

Back to Contents

Table 6.7 shows the number of apprenticeship achievements in 2014/15 by level and age. As might be expected, across all Sector Subject Areas, those aged under 19 tend to be more concentrated in Intermediate Apprenticeships, but they still comprise only 30% of the total achieving an apprenticeship (ie the majority are older). Across the engineering-related Sector Subject Areas, the data confirms that apprentices are younger, with the under 19s comprising about 40% of the total at each level. Apprentices in construction-related areas are particularly young, but much more focused on Intermediate Apprenticeships than in engineering and manufacturing, where under 19s are more evenly split between intermediate and advanced levels.

Table 6.7: Apprenticeship achievements by Sector Subject Area, level and age (2014/15) – England

	Age	Intermediate apprenticeship	Advanced apprenticeship	Higher apprenticeship	All apprenticeships
Construction, planning and the built environment	Under 19	4,010	810	-	4,820
	19-24	1,850	1,070	10	2,930
	25+	520	190	-	710
	All ages	6,380	2,070	20	8,470
	Percentage of all apprentices aged under 19	62.9%	39.1%	-	56.9%
Engineering and manufacturing technologies	Under 19	8,980	6,410	40	15,430
	19-24	6,940	7,070	50	14,060
	25+	9,000	2,540	-	11,550
	All ages	24,920	16,020	90	41,040
	Percentage of all apprentices aged under 19	36.0%	40.0%	44.4%	37.6%
Information and communication technology	Under 19	680	2,600	160	3,430
	19-24	1,130	2,130	220	3,480
	25+	940	950	20	1,900
	All ages	2,740	5,690	390	8,820
	Percentage of all apprentices aged under 19	24.8%	45.7%	41.0%	38.9%
Sub-total all engineering related sector subject areas	Under 19	13,670	9,820	200	23,680
	19-24	9,920	10,270	280	20,470
	25+	10,460	3,680	20	14,160
	All ages	34,040	23,780	500	58,330
	Percentage of all apprentices aged under 19	40.2%	41.3%	40.0%	40.6%
Science and mathematics	Under 19	20	100	-	120
	19-24	10	60	-	80
	25+	10	10	-	10
	All ages	40	170	-	210
	Percentage of all apprentices aged under 19	50.0%	58.8%	0.0%	4.8%
All sector subject areas	Under 19	48,200	22,500	300	71,100
	19-24	53,100	37,100	1,100	91,300
	25+	59,100	36,600	2,900	98,500
	All ages	160,300	96,200	4,300	260,900
	Percentage of all apprentices aged under 19	30.1%	23.4%	7.0%	27.3%

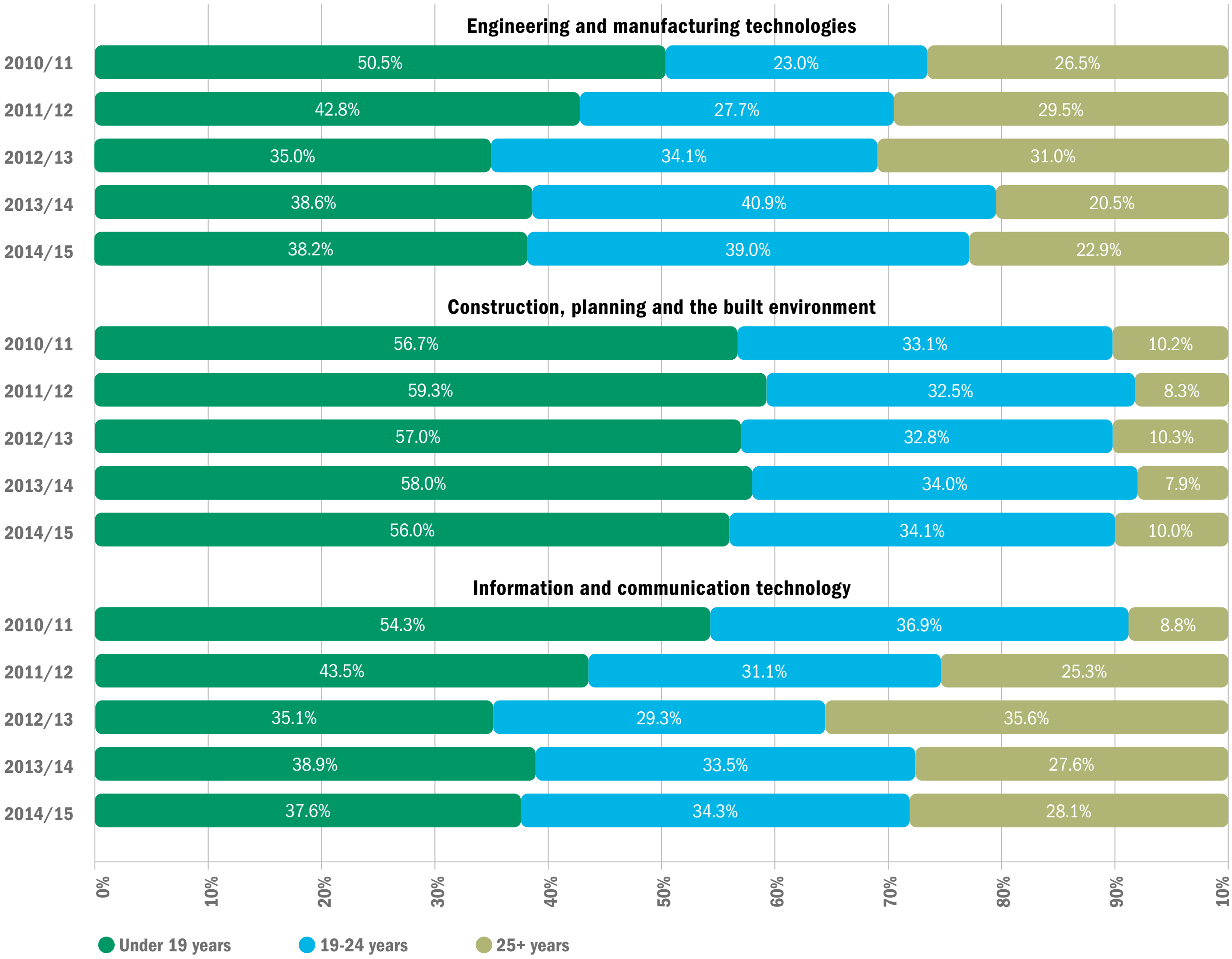
Source: SFA

Figure 6.3 shows the trend in English apprenticeship achievements in engineering-related Sector Subject Areas by age. The changes in profiles over time are similar to the pattern seen for apprenticeship starts by age, with an increase in the proportion of 19- to 24-year-olds and a decrease in younger participants for engineering and manufacturing. Again this is in the construction-related area that young apprentices consistently dominate.

While nearly 53% of the total of 261,000 apprenticeship sector framework achievements (ie across all subject areas) were by women in 2014/15, the proportion for engineering-related frameworks was much lower at 7.4%. Table 6.8 shows the gender profile of achievements in 2014/15 across the different sector frameworks, demonstrating quite a wide range in the proportion of achievements by female apprentices. Women accounted for over 28% of achievements in aviation operations on the ground and in food manufacture, and 23% in rail services. However, over half of engineering-related apprenticeship achievements were in sector frameworks with 3% or less achievements by women.

Compared with the previous year, which showed no change in the proportion of female apprenticeship achievers, the proportion of

Figure 6.3: Apprenticeship programme achievements in engineering-related Sector Subject Areas, by age (2010/11-2014/15) – England



Source: SFA

female achievements in apprenticeships increased in all but one framework. Overall, the percentage of female achievements increased from 6.6% in 2013/14 to 7.4% in 2014/15. Numerically, this was a rise from 2,730 to 3,440 women within respective totals for engineering-related frameworks of 41,070 (2013/14) and 46,690 (2014/15).

Data on achievements in apprenticeships by ethnicity is less readily available than by gender. However, recent participation statistics suggest that across all sectors around 90% of apprentices are of white origin, although there is some evidence that participation by those of ethnic minority background has been rising faster than overall.[6.34] Nonetheless, if apprenticeships are considered as an entry pathway into the highly-skilled engineering labour market, then their current profile does not suggest that the labour force will become more diverse, but possibly the reverse.

Table 6.8: Apprenticeship framework achievements by sector framework code, level and gender (2014/15)[6.33]

Sector framework code	All	% female
Aviation operations on the ground	730	28.8%
Building services engineering technicians	50	20.0%
Ceramics manufacturing	10	0.0%
Electrical and electronic servicing	10	0.0%
Electrotechnical	2,160	0.9%
Engineering	9,680	3.0%
Engineering construction	290	6.9%
Engineering technology	90	11.1%
Food manufacture	1,830	28.4%
Gas industry	210	0.0%
Glass industry occupations	1,540	0.6%
Heating, ventilation, air conditioning and refrigeration	650	1.5%
Industrial applications	9,750	13.3%
It and telecoms professionals	6,540	9.9%
Land-based service engineering	210	0.0%
Mes plumbing	2,780	1.4%
Polymer processing and signmaking	20	0.0%
Power industry	200	0.0%
Print and printed packaging	240	16.7%
Process technology	170	11.8%
Rail infrastructure engineering	480	2.1%
Rail services	480	22.9%
Rail traction and rolling stock engineering	10	0.0%
Rail transport engineering	970	1.0%
Smart meter installations (dual fuel)	130	7.7%
Transport engineering and maintenance	200	5.0%
Vehicle body and paint operations	820	1.2%
Vehicle fitting	280	3.6%
Vehicle maintenance and repair	5,660	1.4%
Vehicle parts operations	410	7.3%
Water industry	70	14.3%
Wood and timber processing and merchants industry	20	0.0%
Sub-total engineering related frameworks	**46,690**	**7.4%**
Grand total	**260,900**	**52.7%**
Percentage engineering related framework	**17.9%**	**-**

Source: SFA

6.33 Framework sectors with no achievements in 2014/15 have been omitted 6.34 House of Commons: *Briefing paper – apprenticeship statistics: England*, July 2016. http://researchbriefings.parliament.uk/ResearchBriefing/Summary/SN06113

Back to Contents

6.2.4 Employer participation

Having reviewed participation in apprenticeships at an individual level, it is also useful to consider participation organisationally. The number of workplaces that employed apprentices in 2014/15 is shown in Table 6.9 by English region. In total, over 251,000 workplaces were offering apprenticeships across the whole of England; an increase of 4.7% upon the previous year and of nearly half since 2010/11. The greatest annual increase in 2014/15 was in Yorkshire and the Humber (6.4%): 6.4% of organisations employed apprentices here, compared with just 3.4% in the South West. Numerically, London had fewer workplaces employing apprentices than any region other than the North East, but it also had the greatest proportional growth over four years at nearly 70%. The region with the most workplaces employing apprentices was the North West, at 42,000.

These regional trends broadly match the geographical spread of individual participation (seen in Table 6.3). In the context of approximately half a million starters in 2014/15, the 251,000 workplaces participating suggests an average of two starters per workplace.

Table 6.9: Workplaces employing apprentices by region (2010/11–2014/15) in year estimates - England.[6.35, 6.36]

Region	2010/11 full year	2011/12 full year	2012/13 full year	2013/14 full year	2014/15 full year	Change 1 year	Change 5 years
North East	10,730	12,250	14,000	14,550	15,200	4.5%	41.7%
North West	28,840	32,230	37,990	40,080	42,030	4.9%	45.7%
Yorkshire and The Humber	20,090	23,270	26,510	27,560	29,320	6.4%	45.9%
East Midlands	16,960	18,940	22,220	23,280	24,420	4.9%	44.0%
West Midlands	19,080	22,420	25,730	26,890	28,360	5.5%	48.6%
East of England	16,910	19,830	23,010	24,470	25,580	4.5%	51.3%
London	13,490	16,550	20,200	21,780	22,920	5.2%	69.9%
South East	23,420	27,330	32,680	34,380	35,520	3.3%	51.7%
South West	20,960	23,440	26,190	27,170	28,040	3.2%	33.8%
England total	**168,600**	**193,800**	**225,600**	**240,000**	**251,300**	**4.7%**	**49.1%**

Source: SFA

6.3 Apprentices, productivity and success rates

The age of an apprentice has a considerable impact on the productivity benefit of an apprenticeship. Research conducted by Cebr on behalf of EngineeringUK in 2015 revealed that the net productivity benefit of an apprentice over a 10-year period decreases as the age at which they start increases.

As Table 6.10 reveals, each apprentice aged 16-18 on average provides a net productivity benefit of £50,600 over ten years. However, for those aged 25 years and older, the benefit falls to £14,500. This is most likely due to the fact that older apprentices have usually been in work longer than younger ones, and thus command a higher wage whilst training.[6.37]

This difference also has an impact on how long it may take before the employer recoups the cost of funding the apprenticeship. Table 6.11 suggests that an employer can expect to break even on its investment in an apprenticeship after 5 years and 4 months for an apprentice aged under 19 years of age. However, for apprentices aged between 19 and 24, this figure rises to 7 years and 2 months. While for those aged 25 years or older, it will take the employer 8 years and 9 months to recoup the investment in the apprenticeship. This difference is likely to be exacerbated when costs associated with apprentices dropping out of their programme are also factored in.

Table 6.10: EMT net productivity benefit summary: by age group, including drop-out costs, apprentices completing in 2013/14

	Total cost of apprentice incl. salaries and training over 10 year period	Apprentice productive contribution over 10 year period	Net productivity benefit over 10 year period
16-18	£257,300	£307,900	£50,600
19-24	£278,100	£307,900	£29,800
25+	£293,400	£307,900	£14,500
Weighted average	**£275,700**	**£307,900**	**£32,200**

Source: Cebr Analysis

Table 6.11: Employer break-even point per apprentice

	Break-even point: completed apprentice	Break-even point: including drop-out costs
16-18	5 Years 4 months	6 Years 1 months
19-24	7 Years 2 months	8 Years 1 months
25+	8 Years 9 months	9 Years 11 months
Weighted average	**7 years 0 months**	**8 years 0 months**

Source: Cebr Analysis

Table 6.12 displays the success rates[6.38, 6.39] for different levels of apprenticeships in England between 2011/12 and 2014/15. Overall, across all subject areas, success rates have declined slightly at intermediate and advanced levels during this period, and were just over 70% in 2014/15. For apprenticeships in engineering and manufacturing technologies, the success rate across all levels was a little higher at 72%, a slight improvement on 2013/14. The success rate in information and communication technology was slightly higher still at 75%.

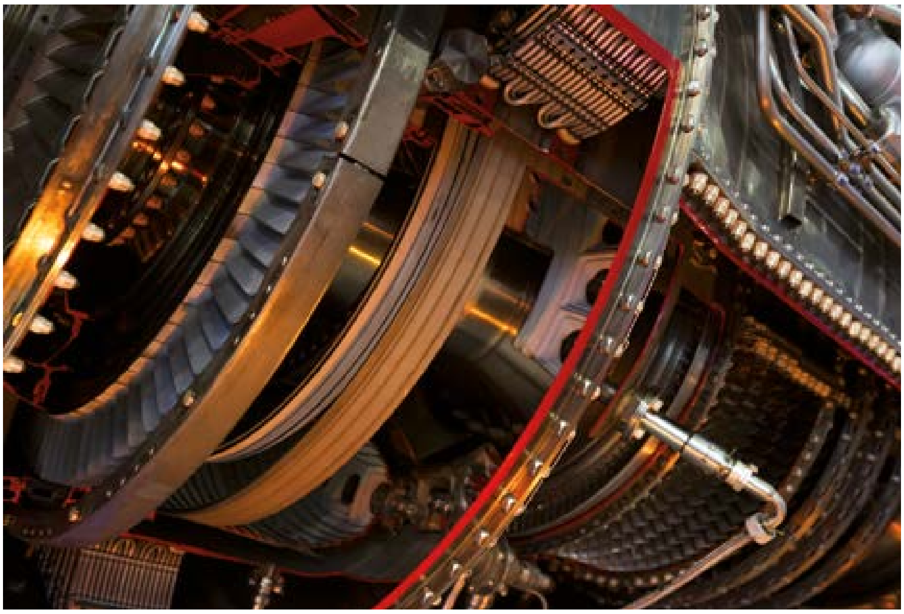
While the overall success rates did not vary much by level, these trends tend to mask variation at different levels, particularly Higher Apprenticeships. As the numbers of participants at this level are much smaller, they do not impact heavily on the changes seen in the success rates for all levels combined. For engineering and manufacturing, and the construction-related area, there is a distinct trend for higher success rates amongst those participating at higher levels.

6.35 The figures are a count of the number of individual workplaces (site level). 6.36 Geographic information is based on the delivery location of the apprenticeship. Note that some workplaces deliver apprenticeships in more than one location. 6.37 Cebr: *Productivity and lifetime earnings impacts of engineering education & training – a report for EngineeringUK*, September 2015, p8. 6.38 Apprenticeship success rates are based on the number of learners who meet all the requirements of their apprenticeship framework, divided by the number of learners who have left training or successfully completed their training in the academic year. 6.39 Success rates are based on the individual apprenticeship frameworks that were completed in the relevant year (the Hybrid End Year).

Table 6.12: Apprenticeship success rates by level (2011/12-2014/15) – England

		2011/12	2012/13	2013/14	2014/15	Change over 1 year	Change over 4 years
Construction, planning and the built environment	Intermediate	66.6%	68.4%	67.2%	66.8%	-0.4%	0.2%
	Advanced	82.8%	81.2%	75.0%	77.3%	2.3%	-5.5%
	Higher	-	-	92.1%	67.5%	-24.6%	-
	All levels	70.9%	72.4%	69.6%	69.2%	-0.4%	-1.7%
Engineering and manufacturing technologies	Intermediate	79.5%	74.7%	70.3%	71.8%	1.5%	-7.7%
	Advanced	78.3%	77.9%	72.9%	77.6%	4.7%	-0.7%
	Higher	94.4%	84.5%	83.5%	78.0%	-5.5%	-16.4%
	All levels	78.8%	76.0%	71.5%	72.3%	0.8%	-6.5%
Information and communication technology	Intermediate	80.5%	70.6%	75.1%	76.3%	1.2%	-4.2%
	Advanced	76.7%	78.5%	77.6%	76.5%	-1.1%	-0.2%
	Higher	43.5%	91.3%	69.8%	69.6%	-0.2%	26.1%
	All levels	79.3%	72.7%	74.7%	75.6%	0.9%	-3.7%
All subject areas	Intermediate	75.2%	73.5%	71.7%	71.2%	-0.5%	-4.0%
	Advanced	74.9%	74.1%	71.2%	71.6%	0.4%	-3.3%
	Higher	64.3%	77.4%	73.3%	68.4%	-4.9%	4.1%
	All levels	74.7%	72.8%	71.3%	70.4%	-0.9%	-4.3%

Source: SFA



6.4 The Industry Apprentice Council

Written by Ann Watson, Semta

The Industry Apprentice Council (IAC) is rapidly establishing itself as a voice within industry for apprentices and the wider FE sector. Its 2016 Annual Survey, the third since the body was established, gives a fascinating insight into life in the workplace for apprentices, covering a range of areas including the wider and changing perceptions of apprenticeships, satisfaction with apprentices' own career choices, and the advice and guidance they were given before becoming an apprentice. These perceptions are all useful in helping to inform the direction of future policy around apprenticeships and skills. Over 1,500 apprentices across the UK took part in the research – the biggest ever response. Although it has been opened up to all sectors, respondents were still dominantly within the engineering-related industries. This article summarises a number of the key findings.

There is a consistent perception that industry apprenticeships (ie those in engineering and related sectors) are more rigorous than some in other sectors, with around three quarters of IAC respondents intimating this perception (in all three IAC surveys to date). Apprentices in industry are on the whole satisfied with their choices – another finding that has remained constant across the three surveys conducted so far – with 97% of male respondents and 96% of females saying they were happy that they had chosen an apprenticeship. Interestingly, there was no difference in these perception rates between those doing different levels of apprenticeship.

Although these respondents had clearly opted for an apprenticeship route, and two thirds had entered from education, not all of them had been aware of progression opportunities within industry as opposed to more academic routes after leaving school. Over half of the male respondents and two-thirds of females said that they had not been fully aware of the opportunities available to them until after they started their apprenticeship. This suggests that industry needs to be bolder in explaining these opportunities to young people, especially young females. This is even more important in light of the 2016 examination results, which show that for many STEM subjects (although not for

Back to Contents

engineering, where male entrants still comprehensively outnumber females) there is near gender parity at GCSE level, only for the proportion of females to drop dramatically at A level. There also remains a huge gender gap in engineering apprenticeships, with just 4% of engineering apprenticeships being started by females.

31%

of female respondents were fully aware of all the options available, compared with

48%

of male respondents

The majority of IAC survey respondents (60%) said that they had neither been encouraged or discouraged during their education to take up an apprenticeship, while 24% had been encouraged and 16% discouraged. Worryingly, the proportion of females who had actively been discouraged (23%) was higher than amongst males (14%), but also higher than the proportion of females who had been encouraged to participate (16%). Given the gender disparity across our industry and across STEM sectors in general, further work needs to be done to discover why this is happening – industry's demand for skills will not be met without increasing the numbers of females that enter it.

The majority of the growth in apprenticeship starts between 2010 and 2015 has been in the 24+ age group, while the numbers of young people starting apprenticeships have remained consistent. So there is a job to be done and the IAC will play its part in spreading the word about apprenticeships to young people. Nearly 500 survey respondents, almost a third of the total, said that they had been into schools to talk about apprenticeships, which was higher than the comparable proportion the year before. Pleasingly, some 90% of those who had been into schools reported that they had had a positive experience, which will hopefully encourage more apprentices to take the plunge themselves.

32%

have visited schools to deliver careers advice or presentations on apprenticeships

90%

had a good experience at the school

Respondents were asked which three things they wanted the government to do to boost apprenticeships. Top of their list was the inclusion of qualifications, with almost a quarter of respondents including this as one of their top three priorities. This was seen to be needed as a measure of how good any training scheme or regime might be, as well as being a way of ensuring that skills are transferable between employers within the sector. This accords well with the current policy direction; where employers want qualifications within new apprenticeship standards they can be included, and where qualifications are included within standards the government will allow levy funding to pay for them. The intelligence coming from both apprentices and employers seems clear – there is a danger of de-skilling sectors if we do away with qualifications in apprenticeships.

Boosting the extent of careers information, advice and guidance was the second most commonly suggested policy, while the third most popular was for government to ensure that all apprentices have employed status (something which is being enacted by the government).

6.4.1 Recommendations

The survey results have been used by Semta and the IAC to make the following recommendations in relation to apprenticeships:

Five point plan

1 / Ensure the quality of apprenticeships is protected as quantity increases

2 / Ensure all young people are aware of the career options open to them

3 / Reform careers information, advice and guidance

4 / Ensure employers offer progression routes to apprentices who are capable of pursuing them

5 / Create a body to represent apprentices

1. Ensure that the quality of apprenticeships is protected as the quantity increases.

Industry apprentices see their apprenticeships as badges of honour – and so do their employers. The government has introduced minimum standards for apprenticeships, which is welcome. However, the government must now be rigorous in ensuring that employers do not flout those standards and that employers do not offer low quality apprenticeships in a rush to recover their apprenticeship levy. The most frequent policy aspiration amongst survey respondents was for qualifications to be included. The government should consider whether this would be suitable for all sectors, and whether mandating the inclusion of qualifications in all apprenticeships would be the right safeguard against lowering standards.

2. Work with employers to ensure that all young people are aware of the career options open to them in industry if they choose an apprenticeship.

The gender disparity in awareness of career options in industry is concerning, especially given the gender gaps that still exist across STEM sectors. Young people have to be shown that their apprenticeships will lead to a great career. The www.stemexperience.co.uk online platform offers a variety of work experience opportunities within industry for people of all ages.

3. Ensure that all young people are aware of the career options open to them in industry if they choose an apprenticeship.

The gender disparity in awareness of career options in industry is concerning, especially given the gender gaps that still exist across STEM sectors. Young people need to be shown that their apprenticeships will lead to a great career. This is increasingly being addressed and the government is considering mandating that industry-based progression pathways are given equal prominence to academic routes within the careers information and guidance provided by schools.

4. Ensure employers offer progression routes to apprentices who are capable of pursuing them.

The proportion of IAC survey respondents who are not offered opportunities to progress further has been declining, which is welcome. An apprenticeship is a job with training, and must be seen as a pathway to a great career. With the majority of apprenticeships created since 2010 at level 2 (GCSE-equivalent), progression routes are necessary to move towards the high-skill, high-wage economy that the government wants to create. Qualifications are one way to give apprentices evidence of their progress and to ensure that their skills are transferable and quality is embedded.

5. Create a body to represent apprentices.

The National Union of Students is effective in campaigning for students in further and higher education, but does not fully represent the interests of apprentices. Consideration should be given to the needs of all apprentices and how they can be represented effectively.

6.5 Engineering-related apprenticeships in the devolved nations

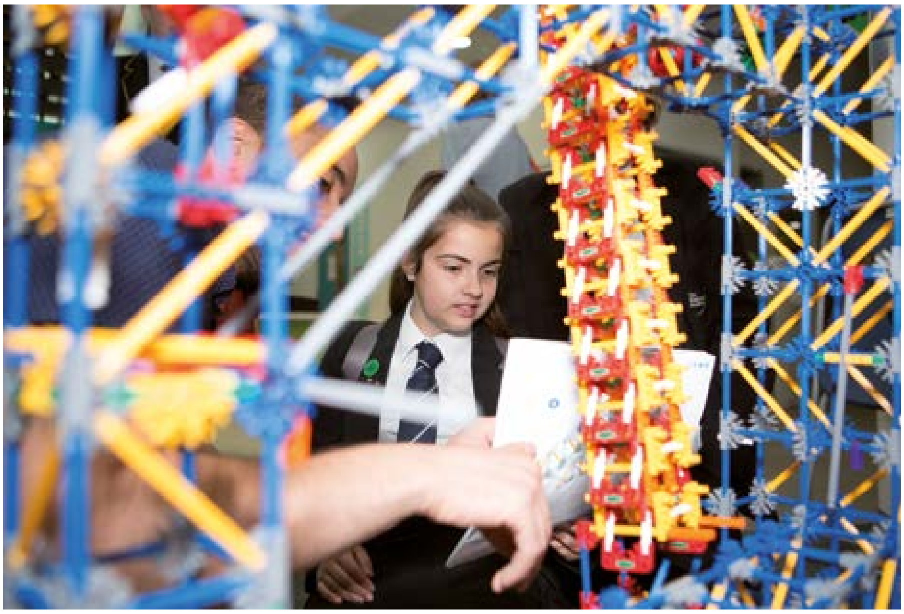
6.5.1 Engineering-related apprenticeships in Scotland

In Scotland, the term 'Modern Apprenticeships' refers to all apprenticeships that are approved by its Modern Apprenticeships Group and thereby qualify for public sector funding. Table 6.13 provides an indication of Modern Apprenticeship starts in Scotland in the last three years, by level. There were just under 8,000 starts in engineering-related frameworks: nearly a third of all starts (broadly equivalent to level 6 of the Scottish Credit and Qualifications Framework). These numbers have been relatively consistent over the last three years. The proportion of all apprenticeships that are in engineering-related areas is therefore higher in Scotland than in England (where it is about 22%).

The most popular engineering-related frameworks in terms of starter numbers are construction, building, automotive, IT and telecommunications (all of which have been growing), engineering and electrical installation (which have decreased in popularity).

Table 6.14 illustrates the gender and age profile of starters in engineering-related Modern Apprenticeship frameworks in Scotland between 2012/13 and 2014/15. Overall, 40% of all starters in 2014/15 were female, but for the last two years, only 4% of starters on engineering-related frameworks were female. Although ICT, engineering, construction, and IT and telecommunications frameworks had higher proportions of female starters, they were still only in the 9-14% range.

Analysis by age group shows that the largest group of starters is also the youngest: 52% of all starters were age 16-19. For engineering-related frameworks, this proportion was slightly greater at 60%. As the age groupings used in Scotland differ from those used in England, it is not clear whether there is a difference in age profile between the two countries, but there does seem to be an even lower proportion of female starters in engineering-related frameworks in Scotland than in England.



The pattern of Modern Apprenticeships achievements differed from the pattern of starts in 2014/15. At 28%, the number of engineering-related achievements was lower than the proportion of starts, and showed a decline of nearly 8% on the previous year: more than the all-subject decline of 6% (Table 6.15). Detailed investigation of the data reveals that there were relatively high proportional changes between years for many framework sectors, presumably due in part to the relatively small numbers involved.

Achievements are not broken down by gender here, but females have represented around 43% of all achievements, across all subjects, since 2012/13. Over the same period, female achievements in engineering-related frameworks have declined from 9% of all achievements in 2012/13 to only 3% in 2014/15. This reflects marked reductions in participation by females in all age groups in engineering-related frameworks, including sectors where there has been a relatively high proportion of female apprentices. For instance, in food manufacture, the proportion of females was 22% in 2014/15 but it had been almost twice this in 2013/14.

Table 6.13: Engineering-related Modern Apprenticeship starts by level (2012/13 to 2014/15) – Scotland

	Level 2			Level 3			Level 4			Level 5			All levels				
	2012/13	2013/14	2014/15	2012/13	2013/14	2014/15	2012/13	2013/14	2014/15	2012/13	2013/14	2014/15	2012/13	2013/14	2014/15	Change 1 year	Change across 3 years
Automotive	111	78	80	792	969	1,038	0	0	0	0	0	0	903	1,047	1,118	6.8%	23.8%
Bus and coach engineering and maintenance	0	0	0	17	12	29	0	0	0	0	0	0	17	12	29	141.7%	70.6%
Construction	50	2	0	61	26	28	2	0	0	0	0	0	113	28	28	0.0%	-75.2%
Construction: building	9	1	24	0	1,171	1,225	0	0	0	0	0	0	9	1,172	1,249	6.6%	13,777.8%
Construction: civil engineering	59	470	468	0	47	50	0	0	0	0	0	0	59	517	518	0.2%	778.0%
Construction (civil engineering and specialist sector)	589	9	1	0	0	0	0	0	0	0	0	0	589	9	1	-88.9%	-99.8%
Construction (craft operations)	0	0	0	1,006	27	21	0	0	0	0	0	0	1,006	27	21	-22.2%	-97.9%
Construction: professional apprenticeship	-	0	0	-	0	0	-	0	0	-	68	74	0	68	74	8.8%	-
Construction: specialist	52	159	191	0	4	13	0	0	0	0	0	0	52	163	204	25.2%	292.3%
Construction (technical operations)	0	0	0	339	337	0	265	166	0	61	24	0	665	527	0	-100.0%	-100.0%
Construction: technical	-	0	0	-	226	602	-	0	0	-	0	0	0	226	602	166.4%	-
Construction: technical apprenticeship	-	0	0	-	0	0	-	246	289	-	0	0	0	246	289	17.5%	-
Electrical installation	0	0	0	568	693	615	0	0	0	0	0	0	568	693	615	-11.3%	8.3%
Electronic security systems	-	0	0	-	28	59	-	0	0	-	0	0	0	28	59	110.7%	-
Electrotechnical services	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	-	-100.0%
Engineering	0	0	0	1,429	1,469	1,364	0	0	0	0	0	0	1,429	1,469	1,364	-7.1%	-4.5%
Engineering construction	0	0	0	63	73	54	0	0	0	0	0	0	63	73	54	-26.0%	-14.3%
Extractive and mineral processing	120	96	99	58	13	20	0	0	0	0	0	0	178	109	119	9.2%	-33.1%
Food manufacture	1,077	21	0	135	2	0	0	0	0	0	0	0	1,212	23	0	-100.0%	-100.0%
Gas industry	0	0	0	38	35	29	0	0	0	0	0	0	38	35	29	-17.1%	-23.7%
Glass industry operations	95	177	171	40	54	27	0	0	0	0	0	0	135	231	198	-14.3%	46.7%
Heating, ventilation, air conditioning and refrigeration	0	0	0	83	96	94	0	0	0	0	0	0	83	96	94	-2.1%	13.3%
Information and communication technologies profession	0	0	0	468	95	84	0	0	0	0	0	0	468	95	84	-11.6%	-82.1%
It and telecommunications	-	1	8	-	424	603	-	0	23	-	0	0	0	425	634	49.2%	-
Land-based engineering	55	37	27	10	11	7	0	0	0	0	0	0	65	48	34	-29.2%	-47.7%
Oil and gas extraction	0	0	0	133	120	120	0	0	0	0	0	0	133	120	120	0.0%	-9.8%
Plumbing	0	0	0	295	289	356	0	0	0	0	0	0	295	289	356	23.2%	20.7%
Polymer processing	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	-
Power distribution	28	54	41	0	0	0	0	0	0	0	0	0	28	54	41	-24.1%	46.4%
Printing	8	0	0	1	0	1	0	0	0	0	0	0	9	0	1	-	-88.9%
Process manufacturing	0	0	0	37	39	45	0	0	0	0	0	0	37	39	45	15.4%	21.6%
Vehicle body and paint operations	0	0	0	2	0	0	0	0	0	0	0	0	2	0	0	-	-100.0%
Vehicle maintenance and repair	0	0	0	6	4	0	0	0	0	0	0	0	6	4	0	-100.0%	-100.0%
Water industry	2	0	6	32	6	6	0	0	0	0	0	0	34	6	12	100.0%	-64.7%
Wind turbine operations and maintenance	0	0	0	17	8	2	0	0	0	0	0	0	17	8	2	-75.0%	-88.2%
Subtotal all engineering frameworks	**2,255**	**1,105**	**1,116**	**5,631**	**6,278**	**6,492**	**267**	**412**	**312**	**61**	**92**	**74**	**8,214**	**7,887**	**7,994**	**1.4%**	**-2.7%**
All frameworks	**10,781**	**9,629**	**9,135**	**14,339**	**14,805**	**15,469**	**496**	**726**	**547**	**75**	**124**	**96**	**25,691**	**25,284**	**25,247**	**-0.1%**	**-1.7%**
Percentage engineering frameworks	**20.9%**	**11.5%**	**12.2%**	**39.3%**	**42.4%**	**42.0%**	**53.8%**	**56.7%**	**57.0%**	**81.3%**	**74.2%**	**77.1%**	**32.0%**	**31.2%**	**31.7%**	**-**	**-**

Source: Skills Development Scotland

Table 6.14: Engineering-related Modern Apprenticeship starts by gender and age (2012/13-2014/15) – Scotland

	16-19				20-24				25+				All ages			
	Total		Female		Total		Female		Total		Female		Total		Female	
	2013/14	2014/15	2013/14	2014/15	2013/14	2014/15	2013/14	2014/15	2013/14	2014/15	2013/14	2014/15	2013/14	2014/15	2013/14	2014/15
Automotive	852	960	11	19	118	104	5	7	77	54	0	2	929	1,118	1.7%	2.5%
Biotechnology	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	-
Bus and coach engineering and maintenance	11	13	0	0	1	12	0	0	0	4	0	0	11	29	0.0%	0.0%
Chemicals manufacturing and petroleum industries	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	-
Construction	9	5	1	0	19	21	0	0	0	2	0	0	9	28	11.1%	0.0%
Construction: building	911	993	16	15	203	191	9	6	58	65	1	4	969	1,249	2.7%	2.0%
Construction: civil engineering	250	229	3	2	57	74	0	0	210	215	1	0	460	518	0.9%	0.4%
Construction (civil engineering and specialist sector)	8	0	0	0	0	0	0	0	1	1	0	0	9	1	0.0%	0.0%
Construction (craft operations)	6	2	0	0	19	17	1	0	2	2	0	0	8	21	12.5%	0.0%
Construction: professional apprenticeship	0	0	0	0	0	0	0	0	68	74	1	2	68	74	1.5%	2.7%
Construction: specialist	62	81	0	0	52	68	0	0	49	55	0	2	111	204	0.0%	1.0%
Construction (technical operations)	33	0	4	0	32	0	0	0	462	0	14	0	495	0	3.6%	-
Construction: technical	5	55	0	5	12	61	1	7	209	486	6	32	214	602	3.3%	7.3%
Construction: technical apprenticeship	0	0	0	0	19	15	1	0	227	274	9	7	227	289	4.4%	2.4%
Electrical installation	439	404	7	3	111	113	3	2	143	98	1	0	582	615	1.9%	0.8%
Electricity industry	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	-
Electronic security systems	22	41	0	0	6	18	0	1	0	0	0	0	22	59	0.0%	1.7%
Electrotechnical services	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	-
Engineering	1,164	1,063	55	45	193	220	8	13	112	81	5	3	1,276	1,364	5.3%	4.5%
Engineering construction	44	30	2	2	28	16	2	2	1	8	0	1	45	54	8.9%	9.3%
Extractive and mineral processing	5	9	1	5	4	9	1	0	100	101	4	0	105	119	5.7%	4.2%
Food manufacture	4	0	1	0	4	0	1	0	15	0	6	0	19	0	42.1%	-
Gas industry	31	24	0	0	3	4	0	0	1	1	0	0	32	29	0.0%	0.0%
Glass industry operations	13	22	0	0	33	26	0	0	185	150	0	0	198	198	0.0%	0.0%
Heating, ventilation, air conditioning and refrigeration	75	66	0	0	7	12	0	0	14	16	0	0	89	94	0.0%	0.0%
Information and communication technologies profession	38	49	3	7	24	35	2	5	33	0	7	0	71	84	16.9%	14.3%
It and telecommunications	222	284	25	20	105	161	23	22	98	189	13	19	320	634	19.1%	9.6%
Land-based engineering	41	27	0	0	7	7	0	0	0	0	0	0	41	34	0.0%	0.0%
Oil and gas extraction	83	87	11	5	30	31	4	1	7	2	2	0	90	120	18.9%	5.0%
Plumbing	233	302	2	1	37	35	1	0	19	19	2	2	252	356	2.0%	0.8%
Polymer processing	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	-
Power distribution	38	32	0	0	14	7	0	0	2	2	0	0	40	41	0.0%	0.0%
Printing	0	0	0	0	0	1	0	0	0	0	0	0	0	1	-	0.0%
Process manufacturing	37	35	4	1	2	8	0	1	0	2	0	0	37	45	10.8%	4.4%
Rail transport engineering	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	-
Vehicle body and paint operations	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	-
Vehicle maintenance and repair	2	0	0	0	1	0	0	0	1	0	0	0	3	0	0.0%	-
Water industry	5	3	0	0	1	3	0	0	0	6	0	0	5	12	0.0%	0.0%
Wind turbine operations and maintenance	4	2	0	0	3	0	1	0	1	0	0	0	5	2	20.0%	0.0%
Subtotal all engineering frameworks	**4,647**	**4,818**	**146**	**146**	**1,145**	**1,269**	**63**	**67**	**2,095**	**1,907**	**72**	**74**	**7,887**	**7,994**	**3.6%**	**3.6%**
All frameworks	**13107**	**13247**	**5616**	**5539**	**6766**	**6877**	**3337**	**3355**	**5411**	**5123**	**1492**	**1275**	**25,284**	**25247**	**41.3%**	**40.3%**
Percentage engineering frameworks	**35.5%**	**36.4%**	**2.6%**	**2.6%**	**16.9%**	**18.5%**	**1.9%**	**2.0%**	**38.7%**	**37.2%**	**4.8%**	**5.8%**	**31.2%**	**31.7%**	**8.6%**	**8.9%**

Source: Skills Development Scotland

Table 6.15: Engineering-related Modern Apprenticeship achievements by level (2012/13-2014/15) – Scotland

	Level 2			Level 3			Level 4			Level 5			Total				
	2012/13	2013/14	2014/15	2012/13	2013/14	2014/15	2012/13	2013/14	2014/15	2012/13	2013/14	2014/15	2012/13	2013/14	2014/15	Change 1 year	Change across 3 years
Automotive	1	28	51	8	44	281	0	0	0	0	0	0	9	72	332	361.1%	3588.9%
Biotechnology	0	0	0	8	6	0	0	0	0	0	0	0	8	6	0	-100.0%	-100.0%
Bus and coach engineering and maintenance	0	0	0	0	1	3	0	0	0	0	0	0	0	1	3	200.0%	-
Chemicals manufacturing and petroleum industries	0	0	0	6	5	1	0	0	0	0	0	0	6	5	1	-80.0%	-83.3%
Construction	390	136	16	1,327	896	706	0	8	2	37	1	0	1,754	1,041	724	-30.5%	-58.7%
Construction: building	0	0	6	0	0	7	0	0	0	0	0	0	0	0	13	-	-
Construction: civil engineering	0	106	323	0	0	0	0	0	0	0	0	0	0	106	323	204.7%	-
Construction (civil engineering and specialist sector)	100	243	158	0	0	0	0	0	0	0	0	0	100	243	158	-35.0%	58.0%
Construction (craft operations)	0	0	0	7	37	72	0	0	0	0	0	0	7	37	72	94.6%	928.6%
Construction: professional apprenticeship	-	0	0	-	0	0	0	0	0	0	4	44	0	4	44	1,000.0%	-
Construction: specialist	0	15	88	0	0	2	0	0	0	0	0	0	0	15	90	500.0%	-
Construction (technical operations)	0	0	0	197	282	132	135	235	46	49	41	11	381	558	189	-66.1%	-50.4%
Construction: technical	-	0	0	-	2	245	-	0	0	-	0	0	0	2	245	12,150.0%	-
Construction: technical apprenticeship	-	0	0	-	0	0	-	20	198	-	0	0	0	20	198	890.0%	-
Electrical installation	0	0	0	23	66	94	0	0	0	0	0	0	23	66	94	42.4%	308.7%
Electricity industry	0	0	0	26	0	0	0	0	0	0	0	0	26	0	0	-	-100.0%
Electrotechnical services	0	0	0	630	470	353	0	0	0	0	0	0	630	470	353	-24.9%	-44.0%
Engineering	0	0	0	924	704	862	0	0	0	0	0	0	924	704	862	22.4%	-6.7%
Engineering construction	0	0	0	66	90	96	0	0	0	0	0	0	66	90	96	6.7%	45.5%
Extractive and mineral processing	35	75	118	20	27	38	4	1	0	0	1	0	59	104	156	50.0%	164.4%
Food manufacture	884	549	98	92	87	45	0	0	0	0	0	0	976	636	143	-77.5%	-85.3%
Gas industry	0	0	0	80	45	15	0	0	0	0	0	0	80	45	15	-66.7%	-81.3%
Glass industry operations	48	80	157	22	27	54	0	0	0	0	0	0	70	107	211	97.2%	201.4%
Heating, ventilation, air conditioning and refrigeration	0	0	0	112	56	58	0	0	0	0	0	0	112	56	58	3.6%	-48.2%
Information and communication technologies profession	0	0	0	194	302	100	0	0	0	0	0	0	194	302	100	-66.9%	-48.5%
It and telecommunications	-	1	1	-	15	229	0	0	0	0	0	0	0	16	230	13,37.5%	-
Land-based engineering	19	81	37	42	46	26	0	0	0	0	0	0	61	127	63	-50.4%	3.3%
Oil and gas extraction	0	0	0	79	92	102	0	0	0	0	0	0	79	92	102	10.9%	29.1%
Plumbing	0	0	0	263	277	238	0	0	0	0	0	0	263	277	238	-14.1%	-9.5%
Printing	1	0	2	8	8	4	0	0	0	0	0	0	9	8	6	-25.0%	-33.3%
Process manufacturing	0	0	0	3	11	17	0	0	0	0	0	0	3	11	17	54.5%	466.7%
Rail transport engineering	0	0	0	3	4	2	0	0	0	0	0	0	3	4	2	-50.0%	-33.3%
Vehicle body and paint operations	0	0	0	54	62	21	0	0	0	0	0	0	54	62	21	-66.1%	-61.1%
Vehicle maintenance and repair	24	11	1	446	474	165	0	0	0	0	0	0	470	485	166	-65.8%	-64.7%
Water industry	0	3	0	1	21	11	0	0	0	0	0	0	1	24	11	-54.2%	1000.0%
Wind turbine operations and maintenance	0	0	0	0	0	4	0	0	0	0	0	0	0	0	4	-	-
Subtotal all engineering frameworks	**1,502**	**1,328**	**1,056**	**4,641**	**4,157**	**3,983**	**139**	**264**	**246**	**86**	**47**	**55**	**6,368**	**5,796**	**5,340**	**-7.9%**	**-16.1%**
All frameworks	**7,994**	**8,079**	**7,434**	**11,184**	**11,927**	**11,438**	**614**	**509**	**437**	**129**	**61**	**78**	**19,921**	**20,576**	**19,387**	**-5.8%**	**-2.7%**
Percentage engineering frameworks	**18.8%**	**16.4%**	**13.1%**	**41.5%**	**34.9%**	**33.4%**	**22.6%**	**51.9%**	**48.3%**	**66.7%**	**77.0%**	**90.2%**	**32.0%**	**28.2%**	**27.5%**	**-**	**-**

Source: Skills Development Scotland

6.5.2 Engineering-related apprenticeships in Wales

Table 6.16 summarises the position in Wales in 2014/15 and the preceding two years, in terms of the number achieving their full apprenticeship framework. Just under 18,000 attained the full framework, slightly above the 2013/14 total which in turn had been markedly higher than in 2012/13. This represented a completion rate of around 85%. Of these attainments, just over 4,000 were in engineering-related subject areas, growth of 5% on the preceding year and 13% on 2012/13. Of these, 42% were at level 3 (termed an 'Apprenticeship' in Wales) and the remainder at level 2 ('Foundation Apprenticeship').

The largest sub-groups of these were in engineering and manufacturing technologies, both at level 2 and level 3, where completion rates were higher at around 90%. Stronger growth was seen in information and communication technology, but from a much smaller 2012/13 base, but completion rates have been falling somewhat in this Sector Subject Area.

Table 6.16: Leavers attaining full framework by apprenticeship type and Sector Subject Area (2012/13-2014/15) – Wales

		Foundation apprenticeships		Apprenticeships		All apprenticeships	
	Year	Leavers attaining full framework	Percentage	Leavers attaining full framework	Percentage	Leavers attaining full framework	Percentage
Engineering and manufacturing technologies	2012/13	1,145	88%	810	92%	1,955	89%
	2013/14	1,180	85%	800	91%	2,000	88%
	2014/15	1,120	85%	845	90%	1,995	87%
Construction, planning and the built environment	2012/13	665	80%	565	81%	1,230	81%
	2013/14	765	80%	525	81%	1,285	81%
	2014/15	970	79%	625	81%	1,600	80%
Information and communication technology	2012/13	275	86%	120	90%	395	87%
	2013/14	320	83%	245	84%	560	83%
	2014/15	220	78%	220	80%	445	79%
Sub-total all engineering related sector subject areas	2012/13	2,085	-	1,495	-	3,580	-
	2013/14	2,265	-	1,570	-	3,845	-
	2014/15	2,310	-	1,690	-	4,040	-
All sector subject areas	2012/13	7,620	85%	5,750	87%	13,370	86%
	2013/14	9,890	84%	7,070	85%	17,715	84%
	2014/15	8,985	82%	7,175	85%	17,805	82%

Source: Welsh government

6.5.3 Engineering-related apprenticeships in Northern Ireland

The number of participants on apprenticeships in Northern Ireland in 2015 is shown in Table 6.17 by framework, level and gender. The total of around 6,300 participants was similar to that reported for the previous year. However, perhaps what is most notable compared to Wales, Scotland or England is the high proportion of all apprentices that were on engineering-related apprenticeships: 63%, which was higher than reported for 2014 (42%). Of these, the largest groups were on frameworks in engineering (1,077, up 25% from 2014), electrotechnical (730, over double the year before) and vehicle maintenance (552, also doubling).

Analysing apprenticeship starts in Northern Ireland (Table 6.18) reveals that, until recently, there was a significant fall in the number of starts (although there was slight growth between 2013/14 and 2014/15). This was driven by a sharp decline in starts from those aged 25 years or older, due to a change in policy in August 2012, when adult apprenticeships were restricted to priority economic sectors (as a move to rebalance the economy).[6.40] This has almost completely offset the recent growth amongst starters in younger age groups. As a result, the age profile of apprentices in Northern Ireland has changed quite radically, becoming younger across the period.

However, these changes have also resulted in a sharp drop in the overall proportion of female apprentices. Until 2012/13, women accounted for the majority of older apprentices, but only a minority of young apprentices. Since then, whilst still a minority of younger apprentices, women are also in the minority in the older age group.

6.40 Nibusinessinfo.co.uk. http://www.nibusinessinfo.co.uk/node/14880

Table 6.17: All participants on apprenticeships by framework (2015) – Northern Ireland[6.41]

Framework	Total	Level 2			Level 3					
					Level 2/3			Level 3 progression		
		Male	Female	Total	Male	Female	Total	Male	Female	Total
Construction	214	211	3	214	0	0	0	0	0	0
Construction crafts	289	0	0	0	40	0	40	246	3	249
Electrical and electronic servicing	18	17	0	17	0	0	0	1	0	1
Electrical distribution and trans. engineering	66	0	0	0	31	1	32	6	28	34
Electrical power engineering	16	6	10	16	0	0	0	0	0	0
Electrotechnical	730	0	0	0	546	0	546	184	0	184
Engineering	1,077	333	7	340	386	20	406	324	7	331
Food manufacture	363	148	139	287	1	3	4	44	28	72
Furniture production	4	3	0	3	0	0	0	1	0	1
Gas utilisation, installation and maintenance	5	0	0	0	3	0	3	2	0	2
Heating, ventilation, air conditioning and refrigeration	45	27	0	27	0	0	0	18	0	18
It and telecoms professional	101	55	21	76	0	0	0	23	2	25
Land based service engineering	60	10	0	10	0	0	0	50	0	50
Light vehicle body and paint operations	48	0	0	0	6	1	7	41	0	41
Mechanical engineering services (plumbing)	275	81	0	81	33	0	33	161	0	161
Print production	12	0	0	0	0	0	0	12	0	12
Printing industry	16	15	1	16	0	0	0	0	0	0
Vehicle body and paint	77	76	1	77	0	0	0	0	0	0
Vehicle fitting	1	1	0	1	0	0	0	0	0	0
Vehicle maintenance and repair	552	147	4	151	109	3	112	286	3	289
Vehicle parts	4	4	0	4	0	0	0	0	0	0
Sub-total all engineering related frameworks	3,973	1,134	186	1,320	1,155	28	1,183	1,399	71	1,470
Total	6,296	1,738	1,279	3,017	640	101	741	1,563	958	2,521
Percentage engineering related frameworks	63.1%	65.2%	14.5%	43.8%	180.5%	27.7%	159.6%	89.5%	7.4%	58.3%

Source: Northern Ireland government

Table 6.18: Apprenticeships starts by age and gender (2007/08-2014/15) – Northern Ireland[6.42]

Academic year	Aged 16 to 19			Aged 20 to 24			Aged 25+			Total
	Male	Female	Total	Male	Female	Total	Male	Female	Total	
2007/08	2,141	649	2,790	621	851	1,472	5	13	18	4,280
2008/09	1,807	670	2,477	697	978	1,675	1,150	2,778	3,928	8,080
2009/10	1,483	618	2,101	770	1,002	1,772	1,412	2,550	3,962	7,835
2010/11	1,158	496	1,654	962	1,216	2,178	1,995	3,121	5,116	8,948
2011/12	1,141	388	1,529	931	1,088	2,019	1,630	2,702	4,332	7,880
2012/13	1,233	396	1,629	1,086	1,258	2,344	915	1,443	2,358	6,331
2013/14	1,521	576	2,097	1,385	1,541	2,926	245	142	387	5,410
2014/15	1,194	275	1,469	574	533	1,107	96	110	206	5,469

Source: Northern Ireland government

6.41 These figures are for apprentices on ApprenticeshipsNI, they do not include those apprentices who remain on Jobskills Modern Apprentices Programme. From August 2012 adult apprenticeships have been restricted to priority economic sectors needed to rebalance the economy. 6.42 From September 2007, apprenticeships in Northern Ireland were aimed at individuals aged 16-24. However, in September 2008 they became all-age apprenticeships. From August 2012, adult apprenticeships have been restricted to the priority economic sectors needed to rebalance the economy.

6.6 Participation in further education

The total number of vocational qualifications across all subjects (in terms of certificates obtained) at level 2 started from 3.8 million in 2011, peaked at over 4.1 million in 2012 and then dropped to 3.1 million by 2015 (Table 6.19). The total numbers at level 3 rose much more consistently over the five-year period, from 1.2 million to 1.8 million, while at levels 4-7 there was little change until 2014. However, between 2014 and 2015, level 4-7 achievements more than doubled (reaching 286,253 in 2015), albeit from a much lower base.

The trends in engineering-related subjects resemble the overall picture but with more fluctuation at subject level. Engineering-related qualifications at level 2 have grown modestly in numbers since 2011 but quite strongly as a proportion of all these qualifications, from around 10% of all level 2 qualifications in 2011 to 14% in 2015. During the same period, the numbers in IT-related subjects dropped, faster than the overall trend.

At level 3, engineering-related subject numbers have broadly kept pace with total growth, at around 12-13% of all qualifications. This reflects a rise in numbers of over 50% across the five-year period. Qualification numbers in IT-related subjects, and science and mathematics, also rose at level 3.

The number of vocational qualifications awarded at levels 4-7 was very much lower than at levels 2 or 3. However, proportionally, this was the area of fastest growth, particularly in the past year, which saw growth both overall and especially in engineering-related subjects.

Table 6.20 illustrates the number of awards in different vocational qualification frameworks in STEM and engineering-related subjects over the past three years and, where available, the proportion achieved by female students. The results show the dramatic reduction in numbers obtaining NVQ/SVQ awards (within the National Qualifications Framework or NQF) and also VRQ awards. This is because these two frameworks were phased out in favour of the Qualifications and Credit Framework (QCF), which itself is being replaced now by the Regulated Quality Framework, (RQF). Where gender data is available, this shows that the proportion of these awards attained by women is low, and tends to be falling further recently for several subject areas and frameworks. In many cases, the numbers for females are below the threshold for reporting, and consequently do not appear in the table.

Table 6.19: Certificates awarded in all vocational qualifications for key STEM and engineering-related subject areas (not including GCSE, AS or A level) in England, Wales and Northern Ireland, at levels 2 to 4+ (2011-2015)

	2011	2012	2013	2014	2015	Change over 1 year	Change over 5 years
Engineering and manufacturing technologies							
Engineering:							
L2	97,660	103,115	104,535	87,600	89,235	1.9%	-8.6%
L3	77,865	51,035	45,015	42,715	73,569	72.2%	-5.5%
L4-7	2,180	3,205	3,190	4,420	14,571	229.7%	568.4%
Manufacturing technologies:							
L2	114,555	109,625	120,315	125,545	126,545	0.8%	10.5%
L3	9,870	11,835	11,665	12,575	28,185	124.1%	185.6%
L4-7	1,045	1,405	990	845	6,955	723.1%	565.6%
Transportation operations and maintenance:							
L2	63,400	66,940	67,990	54,005	67,289	24.6%	6.1%
L3	24,825	19,990	20,990	21,230	32,919	55.1%	32.6%
L4-7	190	130	150	250	2,379	851.6%	1152.1%
Construction, planning and the built environment							
Building and construction:							
L2	119,965	119,750	109,410	108,445	141,177	30.2%	17.7%
L3	34,570	53,725	51,490	54,555	93,953	72.2%	171.8%
L4-7	3,525	3,970	4,005	4,075	14,251	249.7%	304.3%
Urban, rural and regional planning:							
L2	0	0	0	0	0	-	-
L3	0	0	0	0	662	-	-
L4-7	15	10	15	0	0	-	-100.0%
Information and communication technology							
ICT practitioners:							
L2	38,035	52,605	53,150	42,900	17,845	-58.4%	-53.1%
L3	29,595	36,755	41,870	51,970	60,545	16.5%	104.6%
L4-7	1,395	1,195	1,180	1,890	7,504	297.0%	437.9%
ICT for users:							
L2	426,685	431,455	360,775	222,400	128,448	-42.2%	-69.9%
L3	8,185	10,575	11,250	4,860	5,103	5.0%	-37.7%
L4-7	10	10	0	0	17	-	70.0%
Science and mathematics							
Science:							
L2	105,180	146,540	154,630	72,365	16,292	-77.5%	-84.5%
L3	7,615	13,240	18,095	22,875	27,184	18.8%	257.0%
L4-7	310	210	310	315	2,511	697.1%	710.0%
Mathematics and statistics:							
L2	5,205	9,145	16,175	36,590	44,389	21.3%	752.8%
L3	21,955	23,980	25,155	27,345	24,658	-9.8%	12.3%
L4-7	0	0	0	0	0	-	-
Total, all vocational qualifications for all sector subject areas							
L2	3,768,070	4,151,130	4,074,345	3,635,285	3,090,082	-15.0%	-18.0%
L3	1,222,995	1,391,340	1,525,520	1,594,830	1,844,678	15.7%	50.8%
L4-7	129,370	128,120	119,295	115,540	286,253	147.8%	121.3%

Source: Ofqual[6.43]

6.43 Ofqual: *Regulated Qualification Activity Database.* https://www.gov.uk/government/statistical-data-sets/vocational-qualifications-dataset

Table 6.20: Certificates awarded in vocational qualifications for key STEM and engineering-related subject areas (not including GCSE, AS or A level) in England, Wales and Northern Ireland, by framework and gender (2012/13-2014/15)

Sector subject area	Year	Achievements NVQ/SVQ	% Female achievements NVQ/SVQ	Achievements VRQ	% Female achievements VRQ	Achievements QCF	% Female achievements QCF	Total achievements	Total female achievements
Engineering and manufacturing technologies	2012/13	19,400	-	28,400	-	289,800	-	337,600	-
	2013/14	10,800	7.4%	13,100	12.2%	286,600	10.8%	310,500	10.8%
	2014/15	2,000	-	5,600	23.2%	269,400	12.3%	277,000	12.4%
	% change 2013/14 to 2014/15	-81.5%	-	-57.3%	-	-6.0%	-	-10.8%	-
Construction, planning and the built environment	2012/13	8,000	-	10,100	-	225,100	-	243,200	-
	2013/14	4,600	2.2%	4,800	4.2%	222,800	0.0	232,200	2.5%
	2014/15	300	-	1,000	10.0%	232,300	0.0		-
	% change 2013/14 to 2014/15	-93.5%	-	-79.2%	-	4.3%	-	-100.0%	-
Information and communication technology	2012/13	800	-	224,100	-	310,500	-	535,400	-
	2013/14	300	33.3%	115,300	47.3%	258,200	38.2%	373,800	41.0%
	2014/15	-	-	2,400	41.7%	231,000	36.8%	233,400	36.8%
	% change 2013/14 to 2014/15	-100.0%	-	-97.9%	-	-10.5%	-	-37.6%	-
All engineering related subject areas	2012/13	28,200	-	262,600	-	825,400	-	1,116,200	-
	2013/14	15,700	6.4%	133,200	42.3%	767,600	17.6%	916,500	21.0%
	2014/15	2,300	-	9,000	-	732,700	16.9%	510,400	-
	% change 2013/14 to 2014/15	-85.4%	-	-93.2%	-	-4.5%	-	-44.3%	-

Source: BIS[6.44]

The proportion of female awards was much higher in information and communications technology (42% in 2013/14) than in engineering-related subject areas, although it did fall to 37% in 2014/15. The proportion of these qualifications gained by women in engineering and manufacturing technologies and in construction, planning and the built environment were much lower – generally under 10% and in some cases much lower than this.

As we highlighted in the opening section of this chapter, traineeships have been introduced as a short (six week to six month) programme to prepare young people for an apprenticeship or employment. They are initially targeted towards those aged 16-19 not currently in a job and with little work experience. The take-up of traineeships has grown substantially for those under 19, rising by nearly two-thirds from their introduction in 2013 to 2014/15 (Table 6.21). Interestingly, the rate of increase for those aged 19-23 was even faster, more than doubling that year, perhaps reflecting the strong interest in participation in apprenticeships by this somewhat older age group.

In terms of numbers progressing from a traineeship to an apprenticeship programme, there has been an increase of nearly 59% of under 19s and, again, more than double among 19- to 23-year-olds. The percentage rates for progression suggest that more than half of those undertaking traineeships ended up on an apprenticeship programme, although these figures may represent some mixing of cohorts. Of those who failed to complete the programme, a number could have progressed into employment instead, which is another positive and desired outcome of the scheme. However, it is not possible to tell the quality of that employment and therefore how successfully the traineeship contributed to that outcome.

Table 6.21: Number of traineeship starts, completions and progression onto an apprenticeship (2013/14-2014/15) – England[6.45]

	2013/14	2014/15	Percentage change
Traineeship starts	**10,400**	**19,400**	**86.5%**
Under 19	7,000	11,600	65.7%
19-23	3,400	7,800	129.4%
Traineeship completions	**4,800**	**12,600**	**162.5%**
Under 19	3,600	7,400	105.6%
19-23	1,100	5,200	372.7%
Traineeship progression	**4,400**	**7,700**	**75.0%**
Under 19	3,400	5,400	58.8%
19-23	1,000	2,300	130.0%

Source: BIS

6.44 SFA & BIS: *Awards of NVQs/SVQs, VRQs and QCF by gender, level, age, sector subject area and geography*, 2016. https://www.gov.uk/government/statistical-data-sets/fe-data-library-vocational-qualifications--2 and https://www.gov.uk/government/publications/fe-data-library-vocational-qualifications-archive **6.45** SFA: *Further education and skills: learner participation, outcomes and level of highest qualification held.* (Statistical First Release), 2016. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/535589/SFR_commentary_June_2016_final_ofqual_update.pdf

6.7 Addressing skills needs: recognising and rewarding engineering technicians

The demand for science, technology, engineering and maths (STEM) qualified technicians is now well recognised by employers, the engineering profession and government,[6.46] with evidence showing that the need to attract, recognise and increase the number of registered technicians throughout the UK is crucial in delivering economic growth.

With immediate and future technician shortages identified, many employers recognise the need to engage with schools, offer more STEM-based apprenticeships[6.47] and ensure that the appropriate level of skills and quality are developed.

However, research undertaken by the engineering profession has identified that the value provided by technicians and technical careers is not sufficiently recognised and technician careers do not get the credit they deserve.[6.48]

For individuals, professional recognition of their achievement is a key driver for seeking to achieve registration. This is also true of apprentices in the sector. A survey undertaken by the Industry Apprentice Council found that 96.5% of apprentices felt their apprenticeship should lead to professional registration as standard.

Recent major changes in government policy, whereby vocational qualifications and apprenticeships are required to meet professional standards, enable the profession to promote professional registration as a means of improving the recognition and status of technicians and to encouraging more people into technician careers.

Developing pathways to technician registration

Engineering employers, with support from the professional engineering institutions, are working to address skills needs through the development of attractive vocational pathways to professional registration, particularly through the apprenticeship route.

The engineering profession has always supported and driven high quality vocational pathways to professional registration, and welcomed the requirement for Tech level qualifications in published performance tables to be recognised by a relevant professional engineering institution.[6.49] This will ensure that they align with the Engineering Council's standards for underpinning knowledge[6.50] and with the UK Standard for Professional Engineering Competence (UK-SPEC)[6.51] and the Information and Communications Technology (ICT) Technician Standard,[6.52] enabling the approval of more pathways leading to Engineering Technician (EngTech), ICT Technician (ICT*Tech*) and Incorporated Engineer (IEng) registration.

The Engineering Council's standards for underpinning knowledge, UK-SPEC and the ICT*Tech* Standard provide the framework to develop a globally-recognised apprenticeship programme, offering a benchmark of competence and commitment for continuing professional development. Tech levels and apprenticeships with approved status can be readily recognised through the Engineering Council Approved Qualification and Apprenticeship logos, and are listed on the Engineering Council's website.[6.53]

Engineering Council approved qualification | Engineering Council cymhwyster cymeradwy

Engineering Council approved apprenticeship | Engineering Council prentishiaesh gymeradwy

The ability for individuals to identify approved pathways that lead to professional registration provides the opportunity to attract and develop a talent pipeline of professionally-registered technicians and engineers.

Recognising and rewarding technicians in the workplace

The Engineering Council estimates that across all industries and occupations, more than 1.2 million people are eligible to join the national register as an Engineering Technician (EngTech). The small number of these individuals on the register may suggest that there is a low level of awareness of EngTech registration and the value it can bring to employers and technical staff.

Those employers who actively support professional registration find clear benefits to their employees and to their organisation, finding that registration:

- Demonstrates a competent, qualified technician workforce to regulators, clients and customers;
- Supports the creation of a loyal, keen to learn, enthusiastic and motivated team;
- Supports recruitment and retention of high calibre staff;
- Shows breadth of experience within technicians;
- Develops right behaviours and attitudes and creates achievement focused professional environment;
- Improves morale, raises self-esteem and builds relationships between engineers and technicians;
- Encourages staff to keep up to date and helps identify any gaps to address;
- Promotes a structured development pathway for those employees who wish, who can use EngTech or ICT*Tech* registration as an interim step towards progression to IEng and CEng registration.

6.46 UKCES: *The future of jobs and skills* (web page), 2016. https://www.gov.uk/government/collections/the-future-of-jobs-and-skills 6.47 CBI: CBI/Pearson *Education and skills survey 2014, gateway to growth*, 2014. http://www.ucml.ac.uk/sites/default/files/shapingthefuture/101/gateway-to-growth.pdf 6.48 Project TRaM, 2013 6.49 DfE: *2016 performance tables: technical and vocational qualifications* (guidance), 2014. https://www.gov.uk/government/publications/vocational-qualifications-for-14-to-19-year-olds 6.50 Engineering Council: *Approval of Qualifications and Apprenticeship Programmes* (web page), 2015. http://www.engc.org.uk/education-skills/approval-of-qualifications-and-apprenticeship-programmes 6.51 Engineering Council: UK-SPEC (web page), 2015. http://www.engc.org.uk/ukspec 6.52 Engineering Council: *Information and Communications Technology Technician* (web page), 2015. http://www.engc.org.uk/icttech 6.53 Engineering Council: *Database of Technician Qualifications* (web page), 2015. http://www.engc.org.uk/techdb

Back to Contents

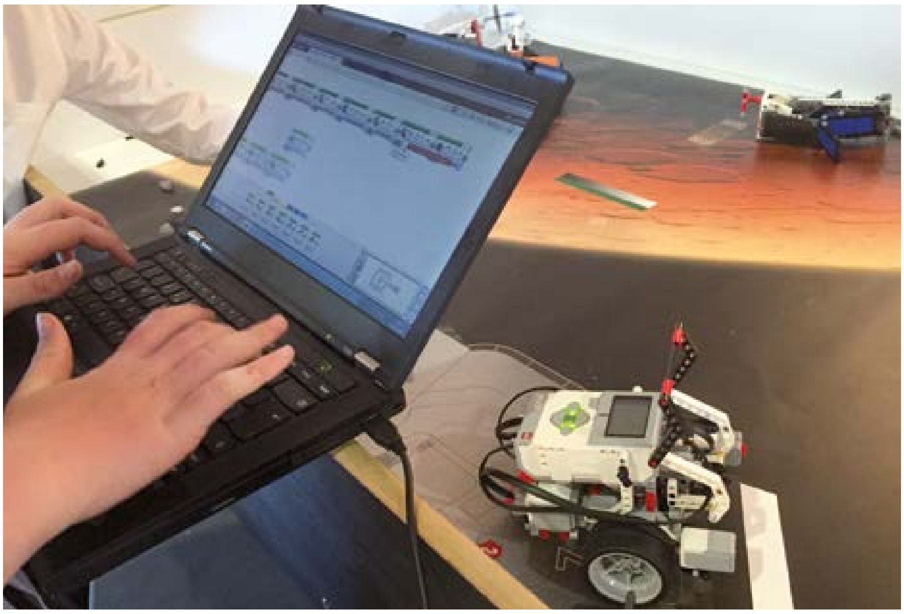
Registered technicians with these employers also state that their employers have shown an increased recognition of their skills and competence, and that they have benefited from an enhanced status within their company and/or industry. It has allowed individuals to develop their own learning, skills and competence, enabling them to stay up to date with the latest industry trends and issues, and ultimately improving their own career prospects.

Developing a professional community

The engineering profession is investing in the development of a professional technician community through the development of a number of collaborative activities aimed at raising the profile of technicians and promoting routes to registration.

The Technician Apprentice Consortium is one such example.[5.54] It brings together employers, professional engineering institutions and colleges, to ensure that business needs are met through the recruitment and training of technician apprentices. By collaborating, the consortium will:

- Ensure that there is a valued work-based route to professional status for aspiring engineers, including those who are currently under-represented within the sector such as females, ethnic minorities and those from disadvantaged backgrounds;
- increase the numbers of young people taking up this route and the number of companies appreciating the benefits it brings and so committing to providing technician apprenticeship places;
- Broaden availability across a range of engineering disciplines, by using UK-SPEC to compile a suite of linked qualifications in conjunction with sector skills councils, professional institutions and awarding bodies.



A collaboration between the Institution of Civil Engineers (ICE), Institution of Mechanical Engineers (IMechE) and the Institution of Engineering and Technology (IET) was formed in 2014 to significantly increase the EngTech population across the engineering sector. The EngTechNow campaign[5.55] promotes professional registration and membership to those working in engineering at technician level, as well as to new entrants into the sector. The key aims are to achieve 100,000 registered EngTechs by 2020, provide a valued membership proposition and establish professional registration for those working in the sector as the expectation by employers and clients.

6.54 Technician Apprenticeship Consortium: *Home page*. http://www.tacnet.org.uk/home/511 **6.55** EngTechNow: *Home page*. http://www.engtechnow.com

Part 2 – Engineering in Education and Training
7 Higher education

Key points

UK higher education (HE) has been booming in recent years. Growth in first degree and postgraduate education is strong, although this is counterbalanced by sharp falls in other undergraduate courses and part-time participation. Record levels of young people are entering HE in England and Wales especially.

Applications

- Application trends showed nearly 5% growth in the number of applicants to engineering courses over the past year – greater than the 2.7% experienced across all subjects;
- There were gains in all engineering sub-disciplines except electrical and electronic engineering;
- Growth was slightly stronger amongst female applicants, but, their proportion remains low for most sub-disciplines except general engineering (over a quarter female) and the growing area of chemical, process and energy engineering.

Entrants – undergraduate

- The UK provided 71% of those entering a UK first degree in engineering in 2014/15, with 6% coming from other EU countries and 23% from other nations;
- Higher proportions of international students studied engineering and computer science than other STEM subjects;
- UK students with an ethnic minority origin are slightly over-represented in engineering, but females are strongly under-represented at around 15%;
- Participation in other forms of undergraduate study (such as HND and HNC) is falling as part of the decrease in part-time HE participation.

Entrants – postgraduate

- In contrast to undergraduate education, in 2014/15 only 31% of taught postgraduates were of UK origin, with 13% from EU nations and 56% from outside the EU – for some sub-disciplines the proportion of international students was 80%;
- Females account for 25% of postgraduates (a higher proportion than undergraduates), reflecting a relatively greater tendency for female engineering graduates (than males) to pursue postgraduate study rather than enter engineering employment.

Qualifications obtained

- There was a 9% increase in first degrees in engineering obtained in 2014/15 over the previous year, 15% of which were by female students;
- The strongest growth was in mechanical and aerospace engineering, while the number of degrees obtained in civil engineering and electrical and electronic fell back slightly;
- At masters level, there was 3% growth, with 75% of all masters obtained by non-UK graduates – in electrical and electronic engineering, 86% of masters degrees were obtained by international students;
- Around 3,000 doctorates were obtained, the majority by international students.

Key factors underlying the trends

- Engineering (and computer science) stands out from other subjects in terms of the nationality profile of students, and is therefore vulnerable both to changes in future immigration policy and perceptions of the UK by prospective international students;
- Postgraduate provision would in many cases not be viable without the participation of international students, who in turn become a high proportion of the HE research and teaching workforce in these strategically important subjects;
- Part-time study continues to decrease (although this could change in future if Degree Apprenticeships really take off);
- For engineering, the severe under-representation of women in HE continues, but varies significantly by sub-discipline and is less pronounced amongst postgraduates;
- The proportion of UK engineering students of ethnic minority origin has doubled over ten years, so that there is now slight over-representation at both first degree and postgraduate level.

In conclusion

Maintaining and ideally increasing the number of engineering graduates from UK higher education in future is likely to be reliant on maintaining the current level of participation of international students, as well as continuing to increase the diversity of the UK student cohort. Efforts need to continue to attract as many suitable prospective HE students as possible onto engineering degree courses.

7.1 Participation in UK higher education

The UK higher education landscape has evolved substantially through the decade before the development of this report (broadly from 2004 to 2014): a period of considerable change in UK higher education policy. Public funding was reduced across the four UK nations, the economy entered a downturn and, in 2012/13, substantially higher undergraduate tuition fees were introduced in England.

UK higher education in 2014/15 comprised over 2.25 million students at 162 universities, two thirds (1,524,225) of whom were studying for first degrees.[7.1] A further 19% (425,270) were studying for postgraduate taught qualifications, 10% for other undergraduate degrees (203,670), and 5% (112,910) postgraduate research programmes. The majority of students – just under 1.7 million – studied full-time (including 88% of those studying first degree programmes). However, this proportion varies strongly at different levels of study: part-time study is more common amongst postgraduates and those studying undergraduate programmes other than first degrees.

As shown in Table 7.1, the total level of participation in UK HE has actually fallen over the last five years, despite the well-known expansion of first degree study. In 2014/15, there were around 2.25 million students, a decrease of 1.4% from 2013/14. During 2014/15, around 160,000 were studying engineering and technology subjects, 1.5% higher than in 2013/14. This continues a slightly rising trend in opposition to the total participation trend.

However, these overall numeric trends mask more complex variations with level and mode of study and also student domicile. For example, overall, during the past five years, there has been substantial growth in participation in full-time first degrees and also in postgraduate taught and research degree programmes. But this has been more than outweighed by significant decreases in participation in part-time (first degree and taught postgraduate) programmes and decreases in both modes of study in participation in other undergraduate programmes.[7.2] There has also been a temporary decline in the size of the population of young people at specific age points.

Significant growth in the proportion of international students has tailed off in recent years. In 2014/15, 5.5% of all students were from other EU countries and 13.8% were from outside the EU, proportions only fractionally above 2013/14 figures.

The UK's decision to leave the European Union following the 2016 referendum, of course, is likely to affect participation in the future. In light of this, the analysis in this chapter focuses quite strongly on participation in first degree and taught postgraduate programmes and how trends differ for UK, other EU and international students, as well as by gender and other student characteristics.

7.2 Applications to UK higher education

Table 7.2 shows that the demand to study engineering subjects at university continues to increase, based on numbers of applicants through the Universities and Colleges Admissions Service (UCAS). In total, there were 718,500 applicants to HE degrees (all subjects) through UCAS in the 2015 application cycle,[7.3] a rise of 2.7% on the previous year.

The 49,375 unique applicants to engineering degrees[7.4] incorporated a rise of 4.7% in applicants compared with the previous year, more than the overall increase across all subjects of 2.7%. Table 7.2 includes applicants of all domiciles who applied through UCAS, although not all international applicants apply through the UCAS system. The number of UK applicants to engineering subjects was 34,985, an increase of 5.7% on the previous cycle. Again, this was higher than the overall increase in UK applicants across all subjects (2.4%).

Table 7.1: Number of students enrolled in higher education (2009/10-2014/15)

	2009/10	2010/11	2011/12	2012/13	2013/14	2014/15	Change 1 Year	Change 5 years
Total students in HE	2,493,420	2,501,295	2,496,645	2,340,275	2,299,355	2,266,075	-1.4%	-9.1%
Engineering and technology students	156,985	160,885	162,020	158,115	159,010	161,445	1.5%	2.8%

Source: HESA

7.1 HESA: *Higher education student enrolments and qualifications obtained at higher education providers in the United Kingdom 2014/15* (Statistical First Release 224), 2016. https://www.hesa.ac.uk/news/14-01-2016/sfr224-enrolments-and-qualifications **7.2** Universities UK: *Patterns and trends in UK higher education*, 2015. http://www.universitiesuk.ac.uk/facts-and-stats/data-and-analysis/Pages/patterns-and-trends-uk-higher-education-2015.aspx **7.3** UCAS data are based on application cycles, i.e. cycle 2015 refers to those applying to start in the academic year 2015/16 **7.4** Data on applicants is sourced from UCAS which changed its method of recording applicant numbers in 2015; this results in apparent larger increases in applicant numbers at the subject level from 2014/15 onwards.

Table 7.2: Unique applicants to STEM subjects by domicile and gender (2010/11-2015/16)

Subject		2010/11	2011/12	2012/13	2013/14	2014/15	2015/16	Change over 1 year	Change over 5 years
	UK	68,495	70,665	65,780	69,360	74,830	78,190	4.5%	14.2%
	EU (excluding UK)	4,315	4,635	4,555	5,065	5,480	6,095	11.2%	41.3%
	Not EU	3,570	3,910	4,440	4,970	5,700	5,170	-9.3%	44.8%
Biological sciences	**Total**	**76,380**	**79,210**	**74,775**	**79,395**	**86,010**	**90,255**	**4.9%**	**18.2%**
	Female	42,135	43,845	41,890	44,745	49,190	53,430	8.6%	26.8%
	% female	55.2%	55.4%	56.0%	56.4%	57.2%	59.2%	2.0%p	4.0%p
	% UK	89.7%	89.2%	88.0%	87.4%	87.0%	85.6%	-1.4%p	-4.1%p
	UK	27,635	29,320	28,230	29,685	30,260	31,410	3.8%	13.7%
	EU (excluding UK)	1,875	2,010	1,865	1,995	2,015	2,280	13.2%	21.6%
	Not EU	2,135	2,140	2,420	2,510	2,980	2,995	0.5%	40.3%
Physical sciences	**Total**	**31,645**	**33,470**	**32,515**	**34,190**	**35,255**	**36,685**	**4.1%**	**15.9%**
	Female	13,125	13,705	13,245	13,890	14,820	15,795	6.6%	20.3%
	% female	41.5%	40.9%	40.7%	40.6%	42.0%	43.1%	1.1%p	1.6%p
	% UK	87.3%	87.6%	86.8%	86.8%	85.8%	85.6%	-0.2%p	-1.7%p
	UK	10,925	10,920	10,340	10,840	10,745	10,910	1.5%	-0.1%
	EU (excluding UK)	820	960	865	830	935	795	-15.0%	-3.0%
	Not EU	2,595	2,590	2,925	2,780	2,730	2,775	1.6%	6.9%
Mathematical sciences	**Total**	**14,340**	**14,470**	**14,130**	**14,450**	**14,410**	**14,670**	**1.8%**	**2.3%**
	Female	5,680	5,760	5,460	5,390	5,395	5,445	0.9%	-4.1%
	% female	39.6%	39.8%	38.6%	37.3%	37.4%	37.1%	-0.3%p	-2.5%p
	% UK	76.2%	75.5%	73.2%	75.0%	74.6%	74.4%	-0.2%p	-1.8%p
	UK	28,570	29,635	28,070	29,680	33,100	34,985	5.7%	22.5%
	EU (excluding UK)	3,820	3,980	3,380	3,500	3,720	4,040	8.6%	5.8%
	Not EU	8,420	8,145	8,715	9,200	10,320	10,345	0.2%	22.9%
Engineering	**Total**	**40,810**	**41,760**	**40,165**	**42,380**	**47,140**	**49,375**	**4.7%**	**21.0%**
	Female	5,600	5,780	6,115	6,665	8,600	9,875	14.8%	76.3%
	% female	13.7%	13.8%	15.2%	15.7%	18.2%	20.0%	1.8%p	6.3%p
	% UK	70.0%	71.0%	69.9%	70.0%	70.2%	70.9%	0.7%p	0.9%p
	UK	27,680	28,250	25,795	27,485	30,045	31,545	5.0%	14.0%
	EU (excluding UK)	1,930	2,330	2,045	2,305	2,650	3,305	24.7%	71.2%
	Not EU	2,215	2,015	2,160	2,305	2,700	3,010	11.5%	35.9%
Computer science	**Total**	**31,825**	**32,595**	**30,000**	**32,095**	**35,395**	**37,860**	**7.0%**	**19.0%**
	Female	5,260	5,355	4,905	5,000	5,510	6,120	11.1%	16.3%
	% female	16.5%	16.4%	16.4%	15.6%	15.6%	16.2%	0.6%p	-0.3%p
	% UK	87.0%	86.7%	86.0%	85.6%	84.9%	83.3%	-1.6%p	-3.7%p
	UK	7,105	6,530	5,400	5,550	5,685	5,100	-10.3%	-28.2%
	EU (excluding UK)	560	620	620	625	720	765	6.3%	36.6%
	Not EU	750	735	710	740	950	865	-8.9%	15.3%
Technology	**Total**	**8,415**	**7,885**	**6,730**	**6,915**	**7,355**	**6,725**	**-8.6%**	**-20.1%**
	Female	1,920	1,585	1,490	1,645	1,895	1,910	0.8%	-0.5%
	% female	22.8%	20.1%	22.1%	23.8%	25.8%	28.4%	2.6%p	5.6%p
	% UK	84.4%	82.8%	80.2%	80.3%	77.3%	75.8%	-1.5%p	-8.6%p

Source: UCAS

In the 2015 application cycle, there were almost 10,000 female applicants to engineering degrees. This represented 20% of applications (Figure 7.1): a slight increase on the 18.2% recorded the previous year and a greater increase in female applicants than that shown by other STEM subjects (Figure 7.2). However, engineering still attracts one of the lower proportions of female applicants to STEM subjects. Only computer science attracts fewer females at 16% (although this proportion too was an increase on the previous year). Biological sciences continues to be the most applied for STEM subject among females, with 59.2% of female applicants – more than the average across all subjects.

7.2.1 Applications to higher education by engineering sub-discipline

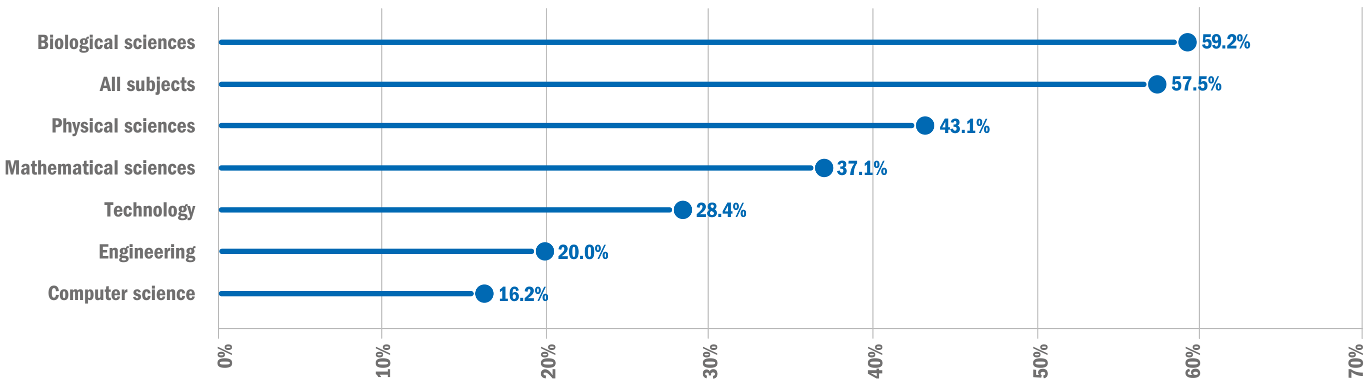
Table 7.3 reveals that there were increases in the number of applicants in 2015, compared with the previous year, for all the engineering sub-disciplines except electrical and electronic engineering which fell by 1.8%. The largest proportional rise was seen for chemical, process and energy engineering (+11.6%) but there were rises of 5% or more for aerospace, mechanical, and production and manufacturing engineering.

When just UK applicants are considered, the one-year proportional increases tended to be stronger still. Chemical, process and energy engineering rose by 16%, and most other sub-disciplines rose by 6% or more. The exceptions were production and manufacturing engineering (+1%) and electrical and electronic engineering (-1%).

Viewed over a five-year period, for all applicants, chemical, process and energy engineering showed the greatest growth (almost doubling since 2010/11). General engineering also grew by over 50% and mechanical engineering by over 30%, while electrical and electronic engineering was little changed and civil engineering applications declined by 15%.

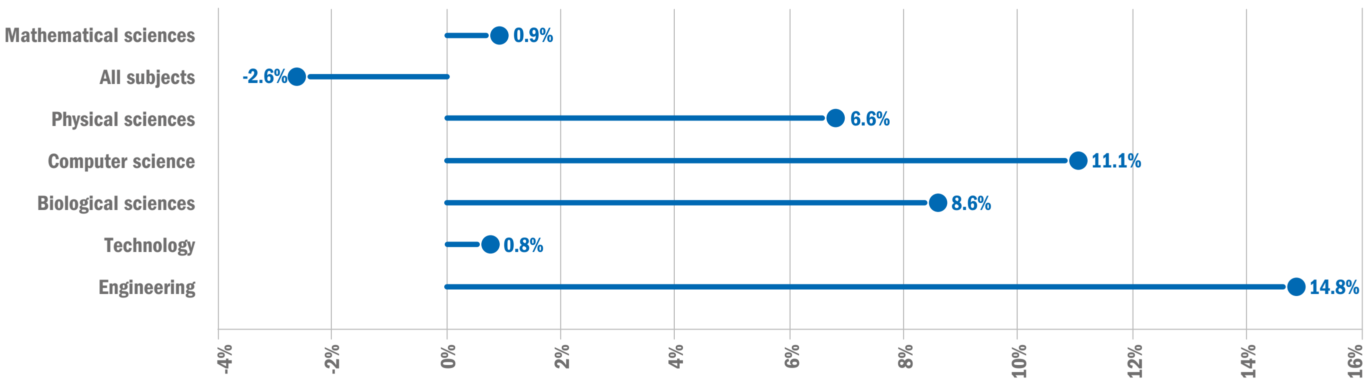
Analysis by gender shows an increase in both the number and proportion of female applicants for all the sub-disciplines compared with 2014/15. Over five-years, chemical, process and energy engineering, and general engineering have had the greatest proportional increases in applications from females. Applications to both these disciplines are now over a quarter female.

Figure 7.1: Percentage of female applicants to STEM subjects (2015/16) – all domiciles



Source: UCAS

Figure 7.2: Percentage change in female applicants to HE subjects (2014/15-2015/16) – all domiciles



Source: UCAS

Table 7.3: Unique applicants to engineering sub-disciplines by domicile and gender (2010/11-2015/16)

		2010/11	2011/12	2012/13	2013/14	2014/15	2015/16	Change over 1 year	Change over 5 years
General engineering	UK	7,485	7,335	7,395	8,590	11,060	11,730	6.1%	56.7%
	EU (excluding UK)	905	940	875	1,070	1,245	1,350	8.4%	49.2%
	Not EU	1,870	1,695	2,095	2,330	2,860	2,715	-5.1%	45.2%
	Total	**10,260**	**9,970**	**10,365**	**11,990**	**15,165**	**15,795**	**4.2%**	**53.9%**
	Female	1,480	1,515	1,925	2,280	3,635	4,255	17.1%	187.5%
	% female	14.4%	15.2%	18.6%	19.0%	24.0%	26.9%	2.9%p	12.5%p
	% UK	73.0%	73.6%	71.3%	71.6%	72.9%	74.3%	1.4%p	-0.1%p
Civil engineering	UK	5,945	5,840	5,060	4,825	4,830	5,175	7.1%	-13.0%
	EU (excluding UK)	1,195	1,140	740	615	595	540	-9.2%	-54.8%
	Not EU	1,625	1,610	1,700	1,655	1,870	1,805	-3.5%	11.1%
	Total	**8,765**	**8,590**	**7,500**	**7,095**	**7,295**	**7,520**	**3.1%**	**-14.2%**
	Female	1,390	1,370	1,290	1,230	1,395	1,455	4.3%	4.7%
	% female	15.9%	15.9%	17.2%	17.3%	19.1%	19.4%	0.3%p	3.5%p
	% UK	67.8%	68.0%	67.5%	68.0%	66.2%	68.8%	2.6%p	1.0%p
Mechanical engineering	UK	9,370	9,895	9,800	10,475	11,330	12,000	5.9%	28.1%
	EU (excluding UK)	1,050	1,120	1,170	1,230	1,295	1,385	6.9%	31.9%
	Not EU	2,420	2,490	2,730	2,985	3,375	3,450	2.2%	42.6%
	Total	**12,840**	**13,505**	**13,700**	**14,690**	**16,000**	**16,835**	**5.2%**	**31.1%**
	Female	1,010	1,130	1,230	1,410	1,690	1,865	10.4%	84.7%
	% female	7.9%	8.4%	9.0%	9.6%	10.6%	11.1%	0.5%p	3.2%p
	% UK	73.0%	73.3%	71.5%	71.3%	70.8%	71.3%	0.5%p	-1.7%p
Aerospace engineering	UK	3,820	3,845	3,715	3,925	4,255	4,570	7.4%	19.6%
	EU (excluding UK)	435	420	415	435	485	640	32.0%	47.1%
	Not EU	1,050	950	855	875	995	940	-5.5%	-10.5%
	Total	**5,305**	**5,215**	**4,985**	**5,235**	**5,735**	**6,150**	**7.2%**	**15.9%**
	Female	590	605	560	615	725	935	29.0%	58.5%
	% female	11.1%	11.6%	11.2%	11.7%	12.6%	15.2%	2.6%p	4.1%p
	% UK	72.0%	73.7%	74.5%	75.0%	74.2%	74.3%	0.1%p	2.3%p
Electronic and electrical engineering	UK	6,795	7,200	6,405	6,630	6,935	6,865	-1.0%	1.0%
	EU (excluding UK)	855	920	795	800	865	840	-2.9%	-1.8%
	Not EU	2,500	2,200	2,280	2,285	2,410	2,325	-3.5%	-7.0%
	Total	**10,150**	**10,320**	**9,480**	**9,715**	**10,210**	**10,030**	**-1.8%**	**-1.2%**
	Female	1,090	1,015	1,030	1,050	1,105	1,150	4.1%	5.5%
	% female	10.7%	9.8%	10.9%	10.8%	10.8%	11.5%	0.7%p	0.8%p
	% UK	66.9%	69.8%	67.6%	68.2%	67.9%	68.4%	0.5%p	1.5%p
Production and manufacturing engineering	UK	2,110	2,195	1,990	2,030	2,000	2,020	1.0%	-4.3%
	EU (excluding UK)	130	175	135	170	145	220	51.7%	69.2%
	Not EU	195	225	240	285	315	370	17.5%	89.7%
	Total	**2,435**	**2,595**	**2,365**	**2,485**	**2,460**	**2,610**	**6.1%**	**7.2%**
	Female	495	550	510	535	510	610	19.6%	23.2%
	% female	20.3%	21.2%	21.6%	21.5%	20.7%	23.4%	2.7%p	3.1%p
	% UK	86.7%	84.6%	84.1%	81.7%	81.3%	77.4%	-3.7%p	-9.3%p
Chemical, process and energy engineering	UK	2,125	2,525	2,810	3,455	4,020	4,670	16.2%	119.8%
	EU (excluding UK)	235	255	260	315	385	425	10.4%	80.9%
	Not EU	1,205	1,245	1,380	1,535	1,830	1,865	1.9%	54.8%
	Total	**3,565**	**4,025**	**4,450**	**5,305**	**6,235**	**6,960**	**11.6%**	**95.2%**
	Female	950	1,050	1,160	1,350	1,620	1,850	14.2%	94.7%
	% female	26.6%	26.1%	26.1%	25.4%	26.0%	26.6%	0.6%p	0.0%p
	% UK	59.6%	62.7%	63.1%	65.1%	64.5%	67.1%	2.6%p	7.5%p

Source: UCAS

Figure 7.3 presents the application data in another way, illustrating the gradual shift in the profile of applicants to engineering sub-disciplines over time. The chart shows progressive increases in the proportion of engineering applicants to chemical, process and energy, and general engineering, and distinct decreases in electrical and electronic and civil engineering. The 2015 application cycle data largely continue these observed trends. Although this depiction uses data for all domiciles of applicant, the same trends are observed when the analysis is undertaken using only UK applicants.

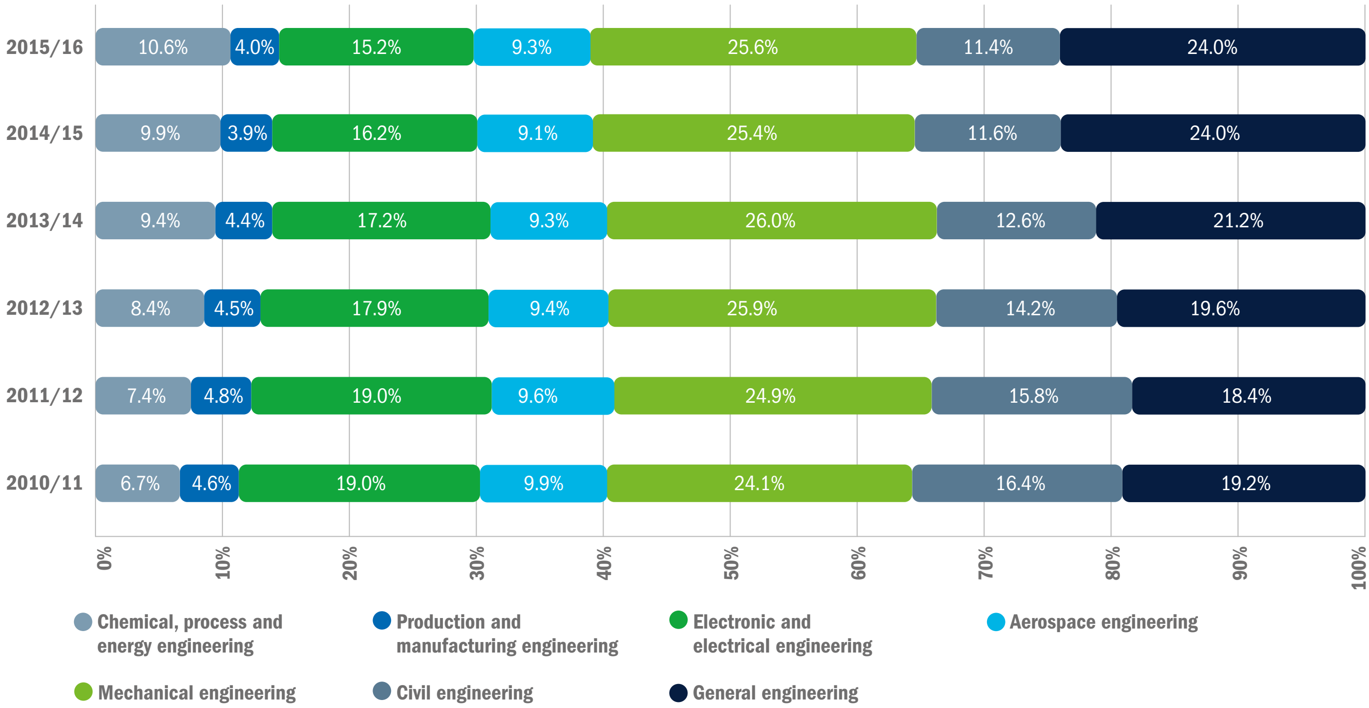
Addressing the gender balance

The chemical, process and energy engineering, and general engineering sub-disciplines have seen the greatest proportional increases in applications over the period analysed, and also have the highest proportions of female applicants (over 26% in each). The strong growth of interest in these sub-disciplines suggests they are promising avenues for addressing the gender balance in the supply chain of young people who could potentially enter the engineering workforce in future.

7.2.2 Qualifications held at entry

It is worth noting that the qualifications held by students entering HE have been becoming increasingly diverse. This can be observed by comparing successive years of 18-year-old UK applicants. Figure 7.4 shows that the most common qualification suite is A levels alone (nearly 20% of applicants). However, the proportion entering HE with BTEC qualifications has risen significantly. In 2015/16, 3.5% had only BTECs (double the extent in 2008) and 2.3% had a combination of BTECs and A levels (nearly

Figure 7.3: Proportion of applicants to engineering subjects by sub-discipline (2010/11-2015/16) – all domiciles

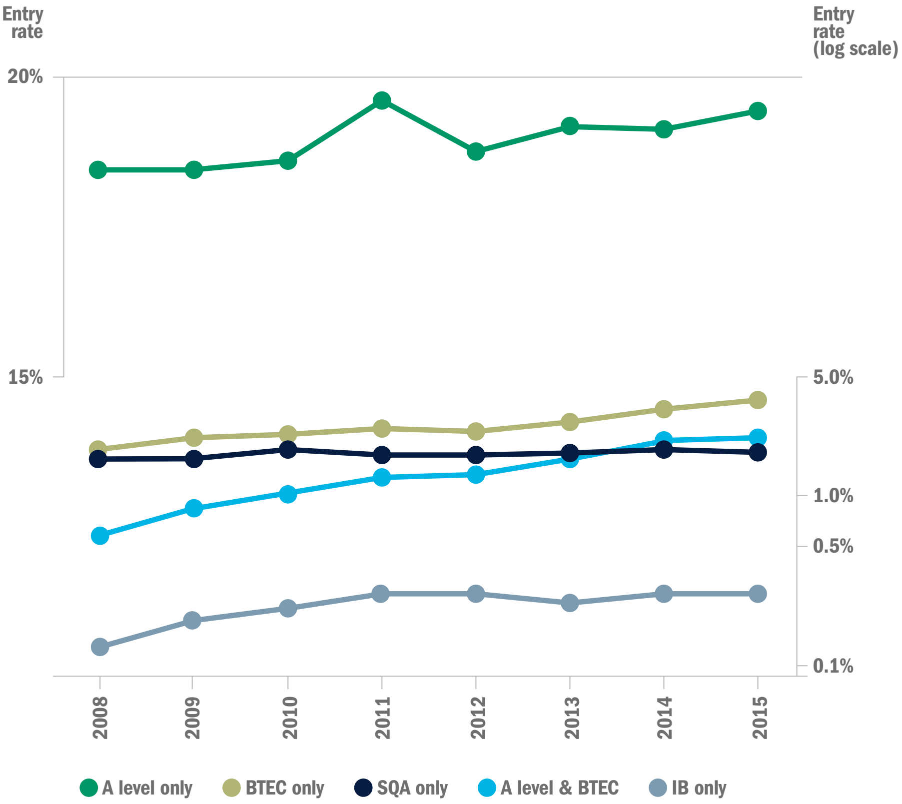


Source: UCAS

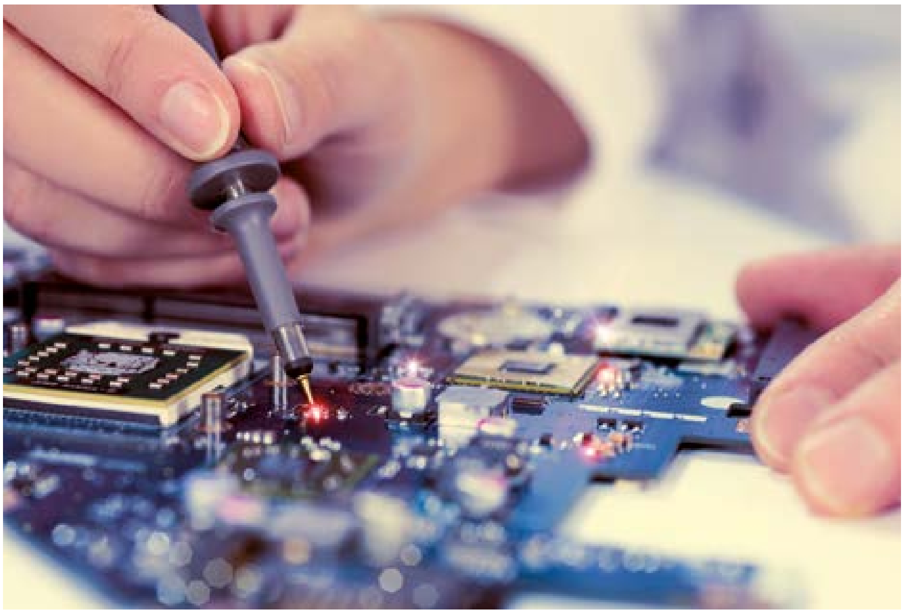
four times the extent in 2008). Almost all of these entrants were from England. Crucially, much of the growth in participation in HE by those from lower socio-economic or disadvantaged backgrounds in recent years has involved entrants with one or more BTEC qualifications.[7.5]

It is thought that around 20% of students completing a level 3 BTEC in engineering progress to a university degree, and over two thirds of these to an engineering degree.[7.6]

Figure 7.4: HE entry rate for UK 18-year-olds by type of qualification held (2008–2015)[7.7]



Source: UCAS



7.3 New enrolments in 2014/15

This section focuses on students starting first degree programmes, other undergraduate programmes and postgraduate programmes in 2014/15. It considers each separately, to reveal the impact of the application trends highlighted earlier in this chapter. Higher Education Statistics Agency (HESA) data on students enrolling in the first year of these programmes has been used for this analysis. This should be more complete than analysis based on accepted applicants from UCAS data, which does not provide full coverage of international students (nor of postgraduate programmes).

The proportion of 18-year-olds who entered HE through UCAS increased by 0.9 percentage points in England to 31.3% in 2015 – the highest recorded entry rate.[7.8] These students will mostly have entered HE in the 2015/16 academic year. The increase means that young people were 3% (proportionally) more likely to enter in 2015 than in the previous cycle, and 27% (proportionally) more likely than in 2006. In Wales, 28.2% of 18-year-olds were placed in HE through UCAS in 2015, an increase of 1.2 percentage points (4% proportionally) – the highest entry rate recorded for Wales. Entry rates for 18-year-olds living in Northern Ireland were already higher than elsewhere in the UK in 2014, at 33.5%, but fell by around 1 percentage point in 2015. This meant that they were about as likely to enter as they had been in 2006.

The entrant data that follows is for 2014/15: at the time of writing, this was the most complete dataset available from HESA.

7.3.1 Entrants to first degree programmes

Table 7.4 shows the number of first year students enrolled on undergraduate first degrees in key STEM subjects at UK universities in 2014/15.

Just under 36,000 students were enrolled on first degree courses in engineering (including the integrated masters courses that lead to MEng degrees). Of these students, 71% (just under 25,500) were UK domiciled, with a further 6% from other EU countries and nearly 23% from outside the EU. The proportion from outside the UK was significantly larger than for other key STEM subjects, and the proportion from other EU nations somewhat higher in engineering and computer sciences than for other STEM subjects or overall.

A slightly higher proportion of engineering students than overall were studying full-time (92%). This probably reflects the comparatively high international student proportion, of whom

7.5 UCAS: *End of cycle report*, December 2015. https://www.ucas.com/sites/default/files/eoc-report-2015-v2.pdf **7.6** Estimate based on data on BTEC completions and subsequent degree subjects from Pearson **7.7** SQA – Scottish Qualifications Authority, IB – International Baccalaureate **7.8** UCAS: – ibid very few study part time. In terms of gender, just over 15% of the first year engineering students were female, fractionally higher than the gender balance in computer sciences, but contrasting with the overall student body of which the majority are female.

Data and comparisons over time

These first year participation numbers are derived from HESA data and are not directly comparable with data presented in recent editions of this publication which used accepted applicants through UCAS. HESA data gives a full picture of first year participation, whereas many international students will not have applied through UCAS (which, on the other hand, may also include applicants who defer entry to a subsequent year). The total number of first year engineering students now reported – nearly 36,000 – is notably higher than the 29,100 UCAS accepted applicants reported for the same academic year. This change in data presentation means that year-on-year comparisons are not made here, but will be resumed in future editions using comparable data.

Table 7.5 breaks the data for engineering and technology first year students down by engineering sub-discipline. It shows that mechanical engineers made up 25% of all first year engineering students. It also illustrates that the proportion of international students is particularly high in electrical and electronic engineering (38.5%), civil engineering (32.2%), and chemical, process and energy engineering (32.3%).

The proportion of female students varies quite strongly by discipline, ranging from 25% of those in chemical, process and energy engineering to less than 10% in mechanical engineering. These differences in the gender profile have also previously been observed in recent years from UCAS accepted applicant data.

Table 7.4: First year students enrolled on first degree undergraduate courses in STEM subjects, by domicile, mode and gender (2014/15) – UK

		UK	Other EU	RoW	Full-time	Female	Total
Biological sciences	Number	55,520	2,560	2,465	54,005	36,475	60,545
	%	91.7%	4.2%	4.1%	89.2%	60.2%	100.0%
Physical sciences	Number	20,880	830	1,380	21,870	9,415	23,090
	%	90.4%	3.6%	6.0%	94.7%	40.8%	100.0%
Mathematical sciences	Number	9,330	475	1,490	10,120	4,330	11,295
	%	82.6%	4.2%	13.2%	89.6%	38.3%	100.0%
Engineering and technology	Number	25,450	2,275	8,115	33,025	5,410	35,850
	%	71.0%	6.4%	22.6%	92.1%	15.1%	100.0%
Computer sciences	Number	22600	1675	1960	23770	3910	26230
	%	86.1%	6.4%	7.5%	90.6%	14.9%	100.0%
All subjects	Number	444,755	26,170	55,950	480,505	292,785	526,885
	%	84.4%	5.0%	10.6%	91.2%	55.6%	100.0%

Source: HESA bespoke data request

Table 7.5: First year students enrolled on first degree undergraduate courses in engineering sub-disciplines, by domicile, mode and gender (2014/15) – UK

		UK	Other EU	RoW	Full-time	Female	Total
General engineering	Number	4,345	350	650	3,935	865	5,340
	%	81.3%	6.6%	12.1%	73.6%	16.2%	100.0%
Civil engineering	Number	3,205	265	1,255	4,385	855	4,730
	%	67.7%	5.6%	26.6%	92.7%	18.1%	100.0%
Mechanical engineering	Number	6,240	580	2,065	8,555	835	8,890
	%	70.2%	6.5%	23.3%	96.3%	9.4%	100.0%
Aerospace engineering	Number	2,235	195	530	2,905	300	2,965
	%	75.4%	6.6%	18.0%	98.0%	10.1%	100.0%
Electrical and electronic engineering	Number	3,965	405	2,080	6,150	825	6,455
	%	61.5%	6.3%	32.2%	95.3%	12.8%	100.0%
Production and manufacturing engineering	Number	810	50	120	820	195	985
	%	82.6%	5.0%	12.4%	83.2%	19.8%	100.0%
Chemical, process and energy engineering	Number	2,190	140	910	3,210	815	3,240
	%	67.6%	4.3%	28.0%	99.0%	25.2%	100.0%
Total engineering and technology	Number	25,450	2,275	8,115	33,025	5,410	35,850
	%	71.0%	6.4%	22.6%	92.1%	15.1%	100.0%

Source: HESA bespoke data request

Table 7.6 shows the ethnic background of UK-domiciled first year students on first degrees in 2014/15, including the 25,500 UK engineering students. This shows that across all subjects, just over 24% of UK first years in 2014/15 were from ethnic minority backgrounds, while 75% were white. Greater proportions of those studying engineering and technology and computer science subjects (both around 30%) were of ethnic minority background. This was driven mainly by an increased proportion of Asian students (who were also over-represented in mathematics). On the other hand, the profile of those studying physical sciences subjects is less ethnically diverse, with over 84% white. While this data is not directly comparable with UCAS accepted applicant data from previous years, these relative differences in ethnic profile for key subjects are seen in both datasets.

7.3.2 Entrants to other undergraduate-level programmes

Higher National Certificates (HNCs) and Diplomas (HNDs) and foundation degrees are vocational qualifications within the spectrum of higher education that are designed to allow progression to professional registration, study of honours and higher HE programmes or enhanced career prospects. They are delivered or accredited by higher education institutions, further education colleges and a range of work-based learning and other alternative providers. The majority of students study them on a part-time basis.

HNCs are level 4 qualifications equivalent to the first year of study on an honours degree programme. They usually take one year to complete on a full-time basis and two years when studied part-time. HNDs are level 5 qualifications, corresponding to the first two years of study on an honours degree programme, and take two years to complete on a full-time basis. Successful completion of either an HNC or HND may enable individuals to progress to the second or third year of a related honours degree respectively.[7.9]

Foundation degrees are qualifications designed to enable people from non-academic educational backgrounds to progress into HE. Admission is assessed individually, based on previous qualifications and relevant industry experience. Foundation degrees are level 5 qualifications, equivalent to two years' study of an honours degree. As work-based qualifications, they enable learners to remain in paid employment whilst studying. Foundation degrees are developed in close collaboration with employers, and in many cases are in applied subjects.

Table 7.6: First year students enrolled on first degree undergraduate courses in STEM subjects, by ethnicity (2014/15) – UK domiciles

		Asian	Black	Other (incl mixed)	White	total
Biological sciences	Number	4,820	3,715	3,035	43,560	55,520
	%	8.7%	6.7%	5.5%	78.5%	100.0%
Physical sciences	Number	1,575	575	920	17,630	20,880
	%	7.5%	2.8%	4.4%	84.4%	100.0%
Mathematical sciences	Number	1,455	380	450	6,960	9,330
	%	15.6%	4.1%	4.8%	74.6%	100.0%
Engineering and technology	Number	3,810	1,990	1,490	17,850	25,450
	%	15.0%	7.8%	5.9%	70.1%	100.0%
Computer sciences	Number	3,645	1,805	1,140	15,755	22,600
	%	16.1%	8.0%	5.0%	69.7%	100.0%
All subjects	Number	46,790	32,880	23,555	337,130	444,755
	%	10.5%	7.4%	5.3%	75.8%	100.0%

Source: HESA bespoke data request

Table 7.7: New enrolments to HNC, HND and foundation degree programmes in STEM subjects, by domicile, mode and gender (2014/15) – UK

		Total	UK	Other EU	RoW	Full-time	Female
Biological sciences	HNC	340	97.9%	1.5%	0.6%	95.0%	54.0%
	HND	265	96.6%	1.9%	1.5%	98.1%	46.0%
	Foundation degree	1,830	98.4%	1.3%	0.3%	82.1%	33.6%
Physical sciences	HNC	80	100.0%	0.0%	0.0%	53.1%	51.9%
	HND	60	98.2%	1.8%	0.0%	93.0%	38.6%
	Foundation degree	350	98.8%	1.1%	0.1%	83.1%	43.8%
Engineering and technology	HNC	2,490	95.9%	1.1%	3.0%	23.0%	5.1%
	HND	605	88.2%	2.3%	9.5%	52.2%	7.1%
	Foundation degree	2,090	97.9%	1.3%	0.8%	55.0%	9.9%
Computer sciences	HNC	280	98.2%	1.4%	0.4%	83.6%	15.7%
	HND	410	97.3%	2.5%	0.2%	85.0%	17.9%
	Foundation degree	890	99.1%	0.6%	0.3%	56.6%	11.1%
All subjects	HNC	6,095	97.2%	1.4%	1.5%	49.5%	30.5%
	HND	3,430	95.2%	2.0%	2.8%	78.1%	38.3%
	Foundation degree	21,020	97.3%	1.4%	1.3%	65.5%	57.2%

Source: HESA bespoke data request

7.9 nidirect: *Higher National Certificates and Higher National Diplomas* (web page). http://www.nidirect.gov.uk/higher-national-certificates-and-higher-national-diplomas

These qualifications are classified as 'other undergraduate' programmes by HESA, which records them where they are offered by an HE institution or a provider that supplies them with student data. However, this does not capture the entire provision as it omits HNC and HND courses offered by some other types of provider. For consistency with previous editions of this report, Table 7.7 shows the extent of participation in courses leading to these qualifications as recorded by HESA, and therefore should be recognised as under-representing the total extent. With this proviso, Table 7.7 shows that in 2014/15 there were 6,095 students enrolled on HNC programmes. Around 40% of these were studying engineering and technology subjects (2,095), one of the most popular subject areas. Just over half this number enrolled on new HND programmes. Engineering subjects attracted a smaller proportion of these students than other subjects, continuing a strong decline in numbers in recent years. Engineering and technology subjects made up around one tenth of those commencing study for a foundation degree.

Over three quarters of students entering HNC programmes and around half entering HND or foundation degree programmes in engineering were studying part-time. Table 7.7 also shows that they were dominantly UK-domiciled, and under 10% of them were female. Although not shown in the table, 88% of the UK-domiciled entrants in 2014/15 to these programmes were white, compared with 89% in 2013/14. The combination of these figures shows clearly that the cohorts of students pursuing these types of qualification are less diverse in terms of domicile, gender and ethnicity than those undertaking first degree programmes at university. However, a much higher proportion are studying part-time (some of whom will already be in the engineering workforce).

Degree accreditation and professional registration

Accreditation of degree programmes by recognised professional and statutory bodies is a mark of assurance that the programmes meet the standards set by a profession. In the UK, the Engineering Council sets and maintains standards for the engineering profession and sets the overall requirements for accreditation.

The Engineering Council licenses 22 professional engineering institutions to undertake the accreditation within these requirements – interpreting them as appropriate for their own sector of the profession – and maintains the public and searchable registers of HE (degree) programmes that are accredited for the purposes of Incorporated Engineer (IEng) or Chartered Engineer (CEng) registration. The engineering institutions use the accreditation process to assess whether specific educational programmes provide some or all of the underpinning knowledge, understanding and skills for eventual registration in as IEng or CEng.

Bachelor's degrees, with or without honours, may be accredited as fully meeting the academic requirements for IEng status. Bachelor's degrees with honours may be accredited as partially meeting the academic requirements for CEng status, and such accredited degrees will also meet the academic requirements for IEng. Integrated MEng degrees may be accredited as fully meeting the academic requirements for CEng status. Postgraduate degrees (MSc or EngD) may be accredited as further learning for the purposes of CEng (for holders of accredited bachelor's degrees). Foundation degrees may be accredited as partially meeting the academic requirements for IEng, and/or approved for the purposes of registration as Engineering Technician (EngTech) or ICT Technician (ICTTech).

Engineering Council accredited degree

Engineering Council gradd achrededig

Accreditation is an accepted and rigorous process that commands respect both in the UK and internationally. It helps students, their parents and advisers choose quality degree programmes. It also confers market advantage to graduates from accredited programmes, both when they are seeking employment and when they decide to seek professional registration. Some employers require graduation from an accredited programme as a minimum qualification.

Universities with accredited degree programmes (from foundation degree through to engineering doctorates) may promote this status through use of the Engineering Council accredited degree logo, provided it is related to the relevant programme. All accredited courses are listed on the Engineering Council's website, which individuals should check to confirm whether a degree is accredited.[7.10]

Accredited degrees are delivered in a range of study modes to diverse learners. There are opportunities for working engineers to study to bachelor's or master's level and beyond without necessarily leaving their jobs. Engineering degrees may be achieved through part-time study, distance learning, blended learning and work-based pathways such as Engineering Gateways. As professional recognition requires demonstration of skills as well as academic achievement, those who work in an engineering role alongside their studies or complete an engineering work placement may be able to reduce their time to IEng or CEng status if they begin to record evidence of their work-based experience early.

Increasingly, the advantages of professional accreditation are being recognised internationally. The UK engineering profession participates in several major international accords, within and outside Europe, which establish the equivalence of engineering and technology degrees.[7.11] In each case, the system of accreditation applied in the UK is fundamental to the acceptance of UK degrees elsewhere. With increasing globalisation, such accords and frameworks are assuming growing importance with employers as a means by which they can be confident in the skills and professionalism of the engineers involved. An accredited programme also has a market advantage for education providers wishing to attract international students to the UK.

7.10 Engineering Council: *Course search* (web page). http://www.engc.org.uk/courses **7.11** Engineering Council: *International Activity* (web page): http://www.engc.org.uk/international

7.3.3 Entrants to taught postgraduate programmes

Taught postgraduate study (including many master's courses, but here excluding PGCE education courses) comprises a significant proportion of all UK higher education and is an especially important element of provision to international students. As Table 7.8 shows, nearly 18,000 students enrolled in 2014/15 in taught postgraduate courses in engineering-related subjects. This number excludes those studying for integrated master's (MEng) courses, as these are included within the first degree data. The total of around 18,000 was around half the number that started first degree undergraduate courses (see Table 7.4). This is a much higher proportion than is seen in many other STEM subjects, where master's-level study is less common.

The profile of taught postgraduates also stands out in terms of nationality and mode of study. In engineering and technology subjects, only just over 31% of students were UK-domiciled, with 13% from other EU nations and the remaining almost 56% from outside the EU. This contrasts with the overall taught postgraduate cohort, where the majority (55%) were UK-domiciled, with just under 9% from other EU nations and 36% from the rest of the world. The nationality profile of those studying computer science was also strongly international, although not to the extent of engineering. Although this position reflects great success in terms of 'exporting' UK engineering postgraduate education to international students, who come to the UK to study, it does mean that there is relatively high exposure to any changes that might occur in relation to international student mobility.

Part-time study accounted for 39% of all taught postgraduate study in 2014/15 – a higher proportion than at undergraduate level (about 9%). Within engineering subjects and computer sciences, this proportion was significantly lower, at just under 20%. This largely results from the high international participation in these subjects, because most international students study full-time.

In terms of gender, females accounted for around a quarter of taught postgraduate students in engineering and computer sciences: a higher proportion than at undergraduate level. This suggests that female engineering and computer science graduates are more likely to pursue postgraduate study than males. In contrast, across all subjects combined, the gender balance is broadly similar at postgraduate and undergraduate level.

Table 7.8: First year students enrolled on taught postgraduate degrees in STEM subjects, by domicile, mode and gender (2014/15) – UK

		UK	Other EU	RoW	Full-time	Female	Total
Biological sciences	Number	10,130	1,315	2,460	9,525	9,175	13,905
	%	72.8%	9.5%	17.7%	68.5%	66.0%	100.0%
Physical sciences	Number	3,335	805	2,235	5,350	2,865	6,375
	%	52.3%	12.6%	35.1%	83.9%	44.9%	100.0%
Mathematical sciences	Number	940	405	1,340	2,305	1,130	2,690
	%	34.9%	15.2%	49.9%	85.8%	42.1%	100.0%
Engineering and technology	Number	5,525	2,375	9,890	14,340	4,355	17,785
	%	31.1%	13.3%	55.6%	80.6%	24.5%	100.0%
Computer sciences	Number	3,185	895	3,775	6,250	2,150	7,850
	%	40.5%	11.4%	48.1%	79.6%	27.4%	100.0%
All subjects	Number	144,620	23,320	95,575	161,620	154,070	263,655
	%	54.9%	8.8%	36.2%	61.3%	58.4%	100.0%

Source: HESA bespoke data request

Table 7.9: First year students enrolled on taught postgraduate degrees in engineering sub-disciplines, by domicile, mode and gender (2014/15) – UK

		UK	Other EU	RoW	Full-time	Female	Total
General engineering	Number	1,180	350	930	1,400	600	2,460
	%	48.0%	14.3%	37.7%	56.9%	24.5%	100.0%
Civil engineering	Number	1,040	430	1,825	2,755	895	3,295
	%	31.5%	13.1%	55.3%	83.7%	27.2%	100.0%
Mechanical engineering	Number	675	385	1,315	1,995	315	2,375
	%	28.4%	16.3%	55.3%	84.0%	13.2%	100.0%
Aerospace engineering	Number	260	315	405	870	140	975
	%	26.5%	32.1%	41.3%	89.3%	14.6%	100.0%
Electrical and electronic engineering	Number	625	270	2,620	3,215	775	3,515
	%	17.8%	7.7%	74.5%	91.5%	22.0%	100.0%
Production and manufacturing engineering	Number	240	160	800	1,070	350	1,200
	%	20.2%	13.4%	66.4%	89.2%	29.3%	100.0%
Chemical, process and energy engineering	Number	485	145	835	1,205	405	1,465
	%	33.1%	10.0%	56.9%	82.1%	27.8%	100.0%
Engineering and technology	Number	5,525	2,375	9,890	14,340	4,355	17,785
	%	31.1%	13.3%	55.6%	80.6%	24.5%	100.0%

Source: HESA bespoke data request

The numbers of first year students on postgraduate courses in the engineering sub-disciplines are shown in Table 7.9. While the relative proportions studying different sub-disciplines were broadly similar to those studying at undergraduate level, the profile of the students in each sub-discipline varied quite considerably. For example, fewer than one in five students on electrical and electronic engineering and also production and manufacturing engineering postgraduate courses were of UK origin, and three quarters of the former were from outside the European Union. The low proportions of UK students suggest that many of these courses would not be viable without international participation.

In comparison, almost half of those enrolled on general engineering postgraduate courses were UK nationals. These variances in international student composition were closely, but inversely, related to the study mode, with high proportions of full-time study in the sub-disciplines where the proportion of international students was high.

Interestingly, the proportions by gender did not vary as strongly between engineering sub-disciplines as they did at undergraduate level (although the proportion of females studying mechanical and aerospace engineering postgraduate courses was again lower than for other sub-disciplines). Nonetheless, in every engineering sub-discipline, the proportion of females was higher at postgraduate level than undergraduate. In the case of chemical, process and energy engineering – which has the highest proportion of females at undergraduate level – the difference was very small.

The ethnicity profile of UK-domiciled taught postgraduate students of engineering and other subjects was very similar to that of first degree undergraduates.

7.4 Qualifications obtained

This section considers the number of students (of all domiciles) who have obtained degree qualifications in engineering in recent years, and were thus eligible to enter the job market and directly contribute to the supply of a skilled STEM workforce. More detailed focus is given to first and postgraduate degrees, where data is the most robust. Foundation degrees, HNCs and HNDs represent a small and declining proportion of qualifications obtained in engineering and technology from higher education institutions, as part of the decline in participation in part-time programmes (although the extent of provision of HNCs and HNDs in engineering-related subjects by some non-university providers is rising).

7.4.1 First degrees obtained

Over the past ten years, there has been substantial growth in the total number of first degrees obtained in UK higher education. For all subjects combined, the total was 395,580 in 2014/15, which was 29% higher than in 2004/05 (although this was around 6% lower than the peak in 2013/14). For engineering and technology subjects, over 25,400 first degrees were obtained in 2014/15, which was 8.8% higher than the previous year, and represented growth of 46% over the ten-year period (Table 7.10). This means that 6.4% of all first degree qualifications obtained were in the engineering subject area in 2014/15. This was the same proportion as in 2004/05, following several years during which this proportion had been lower.

This growth in first degree engineering qualifications was proportionally slightly stronger for females than males: female engineering students obtained 15% of first degree qualifications in 2014/15. Analysis by domicile shows that the strongest growth was in students from outside the EU, which grew more than 80% over ten years, albeit with only slight growth between 2013/14 and 2014/15. Growth in numbers by EU students has been much more modest, and at a lower level than for UK students.

Table 7.10: First degrees achieved in engineering, by domicile and gender (2004/5-2014/15) – UK

		2004/05	2005/06	2006/07	2007/08	2008/09	2009/10	2010/11	2011/12	2012/13	2013/14	2014/15	Change over 1 year	Change over 10 years
Engineering and technology	**Total**	**17,395**	**17,465**	**17,420**	**17,785**	**18,155**	**19,125**	**19,970**	**20,855**	**22,265**	**23,340**	**25,400**	**8.8%**	**46.0%**
	Female	2,260	2,430	2,280	2,370	2,405	2,650	2,710	2,925	3,170	3,220	3,835	19.0%	69.6%
	Male	15,135	15,035	15,140	15,415	15,750	16,475	17,260	17,930	19,095	20,120	21,565	7.2%	42.5%
	% Female	13.0%	13.9%	13.1%	13.3%	13.2%	13.9%	13.6%	14.0%	14.2%	13.8%	15.1%	1.3%p	2.1%p
	UK	12,435	11,900	11,990	11,955	12,085	12,295	12,865	13,680	14,620	15,615	17,400	11.4%	39.9%
	EU	1,575	1,625	1,690	2,745	1,715	1,860	1,780	1,720	1,755	1,680	1,795	7.0%	14.1%
	Non-EU	3,380	3,940	3,740	4,085	4,350	4,970	5,320	5,460	5,890	6,045	6,200	2.5%	83.4%
	Non-UK	4,955	5,565	5,430	6,830	6,065	6,830	7,100	7,180	7,645	7,725	7,995	3.5%	61.4%
	% Non-UK	28.5%	31.9%	31.2%	38.4%	33.4%	35.7%	35.6%	34.4%	34.3%	33.1%	31.5%	-1.6%p	3%p

Source: HESA bespoke data request

Analysing first degree qualifications obtained by engineering sub-discipline (Table 7.11), shows that the strongest growth in the previous year was in mechanical engineering (already the largest sub-discipline, and now up by 9%) and in aerospace engineering. There were declines in civil engineering and electrical and electronic engineering. There were more substantial proportional between-year declines in the number of qualifiers in some of the smaller sub-disciplines but this is likely to be inherent in their relatively small size. Equally, apparently substantial increases or decreases can be seen in different domicile groups, but these tend to reflect changes to relatively small sub-populations.

A key yardstick in relation to degree achievement is the proportion of graduates who attain a first class or upper second class degree, grades which tend to be used when referring to obtaining 'a good degree'. Traditionally, this has been an important threshold used by firms during graduate recruitment, and may be a requirement for entry to postgraduate study. Figure 7.5 reveals that 72.7% of those qualifying with an engineering and technology degree in 2014/15 were awarded a first or upper second class degree. The proportion for engineering subjects is closely in line with the average of 71.4% for all degree subjects, and is an increase on the previous year's figure of 65.6% (which was also close to the proportion across all subjects that year). The proportion who gained first class degrees, however, was higher than overall and higher than for all the other subjects shown here, except for mathematics.

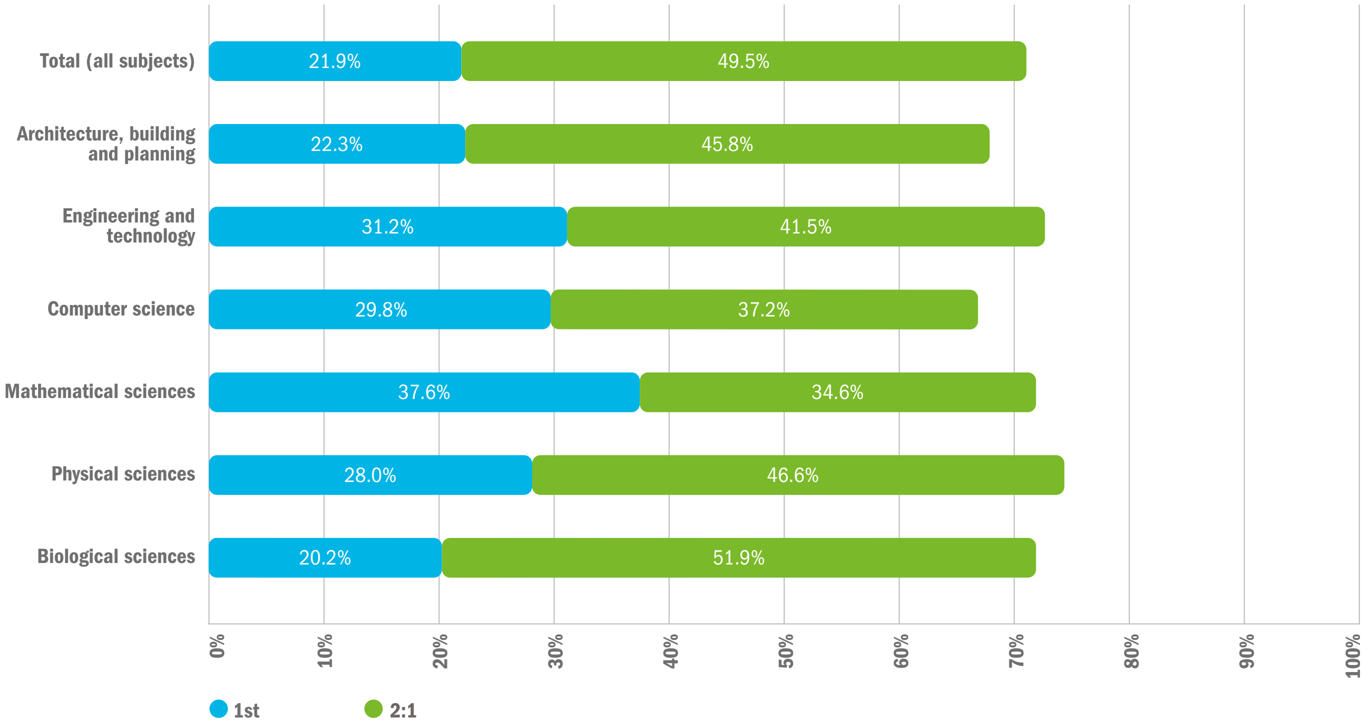
Among the STEM subjects, a somewhat lower proportion of graduates in computer science obtained these 'good' degree classes (65%), while in physical sciences it was a little higher at almost 75%.

Table 7.11: First degrees achieved in engineering sub-disciplines by domicile and gender (2012/13-2014/15) – UK

Sub-disciplines		2012/13	2013/14	2014/15	Change over 1 year
General engineering	**Total**	**1,935**	**2,225**	**2,175**	**-2.1%**
	Female	330	390	370	-5.6%
	Male	1,600	1,835	1,810	-1.5%
	% Female	17.2%	17.6%	16.9%	-0.7%p
	UK	1,430	1,630	1,665	2.1%
	EU	155	185	195	4.9%
	Non-EU	345	410	320	-22.4%
	Non-UK	500	595	510	-13.9%
	% Non-UK	26.0%	26.8%	23.5%	-5.3%p
Civil engineering	**Total**	**4,370**	**4,595**	**4,305**	**-6.3%**
	Female	745	740	700	-5.5%
	Male	3,625	3,855	3,605	-6.5%
	% Female	17.1%	16.1%	16.2%	0.1%p
	UK	3,015	3,170	2,980	-6.0%
	EU	495	445	325	-26.9%
	Non-EU	860	985	1,000	1.5%
	Non-UK	1,360	1,430	1,325	-7.3%
	% Non-UK	31.1%	31.1%	30.8%	-0.3%p
Mechanical engineering	**Total**	**5,665**	**6,060**	**6,610**	**9.1%**
	Female	470	490	545	11.0%
	Male	5,195	5,570	6,070	8.9%
	% Female	8.3%	8.1%	8.2%	0.1%p
	UK	3,935	4,285	4,720	10.2%
	EU	375	410	420	2.6%
	Non-EU	1,355	1,370	1,470	7.2%
	Non-UK	1,730	1,775	1,890	6.4%
	% Non-UK	30.5%	29.3%	28.6%	-0.7%p
Aerospace engineering	**Total**	**1,750**	**1,840**	**1,975**	**7.2%**
	Female	185	190	210	10.7%
	Male	1,565	1,650	1,760	6.7%
	% Female	10.5%	10.3%	10.7%	0.4%p
	UK	1,185	1,280	1,350	5.6%
	EU	120	165	195	18.9%
	Non-EU	445	400	425	6.2%
	Non-UK	560	560	620	10.9%
	% Non-UK	32.2%	30.5%	31.5%	1%p
Electronic and electrical engineering	**Total**	**5,650**	**5,500**	**5,195**	**-5.6%**
	Female	740	705	655	-6.8%
	Male	4,910	4,795	4,535	-5.4%
	% Female	13.1%	12.8%	12.7%	-0.1%p
	UK	3,250	3,140	2,935	-6.6%
	EU	340	310	370	19.2%
	Non-EU	2,060	2,050	1,890	-7.7%
	Non-UK	2,400	2,360	2,260	-4.2%
	% Non-UK	42.5%	42.9%	43.5%	0.6%p
Production and manufacturing engineering	**Total**	**975**	**940**	**810**	**-13.9%**
	Female	190	140	160	12.5%
	Male	785	800	650	-18.6%
	% Female	19.3%	14.8%	19.5%	4.7%p
	UK	650	715	650	-9.3%
	EU	150	40	35	-16.9%
	Non-EU	175	190	125	-33.2%
	Non-UK	325	230	160	-30.3%
	% Non-UK	33.4%	24.3%	19.8%	-4.5%p
Chemical, process and energy engineering	**Total**	**1,680**	**1,910**	**1,925**	**0.8%**
	Female	475	535	530	-0.8%
	Male	1,205	1,375	1,395	1.4%
	% Female	28.4%	28.1%	27.6%	-0.5%p
	UK	1,010	1,240	1,225	-1.1%
	EU	65	90	90	-2.0%
	Non-EU	605	585	610	4.4%
	Non-UK	665	670	700	4.3%
	% Non-UK	39.8%	35.2%	36.3%	1.1%p

Source: HESA bespoke data request

Figure 7.5: Proportion of first degree graduates obtaining first and upper second class degree classes for selected STEM subjects (2014/15) – UK domiciles



Source: HESA

7.4.2 Other undergraduate qualifications obtained

Table 7.12 examines the number of students who obtained key undergraduate qualifications in engineering and technology and computer sciences in 2014/15 that were not first degrees. These include foundation degrees, and HNC and HND programmes. The table also looks at all subjects combined. (The numbers may not cover the entire spectrum of those studying HNC and HND qualifications from all types of provider.)[7.12] Other STEM subjects have been omitted as, in many cases, the numbers are very small for certain types of programme. As indicated previously, in Table 7.7, entrants to these programmes in 2014/15 were predominantly of UK origin and male. A number of these qualifications were mostly studied part-time – most notably engineering HNCs, where four out of five students were part-time.

Table 7.12: HNC, HND and foundation degrees obtained, by domicile (2014/15) – UK

		Total	UK	Other EU	RoW	Full-time	Female
Engineering and technology	Foundation degree	1,425	96.2%	1.9%	1.9%	53.4%	9.2%
	HND	560	88.4%	2.5%	9.1%	51.0%	8.7%
	HNC	1,555	94.7%	2.1%	3.2%	19.0%	5.5%
Computer sciences	Foundation degree	580	99.3%	0.7%	0.0%	56.6%	14.1%
	HND	220	97.7%	0.9%	1.4%	86.8%	10.5%
	HNC	215	97.2%	1.9%	0.9%	77.6%	17.3%
All subjects	Foundation degree	16,850	96.0%	1.6%	2.4%	61.5%	60.0%
	HNC	3,805	96.3%	2.0%	1.7%	47.2%	31.9%
	HND	2,345	94.1%	1.8%	4.1%	81.4%	37.2%

Source: HESA bespoke data request

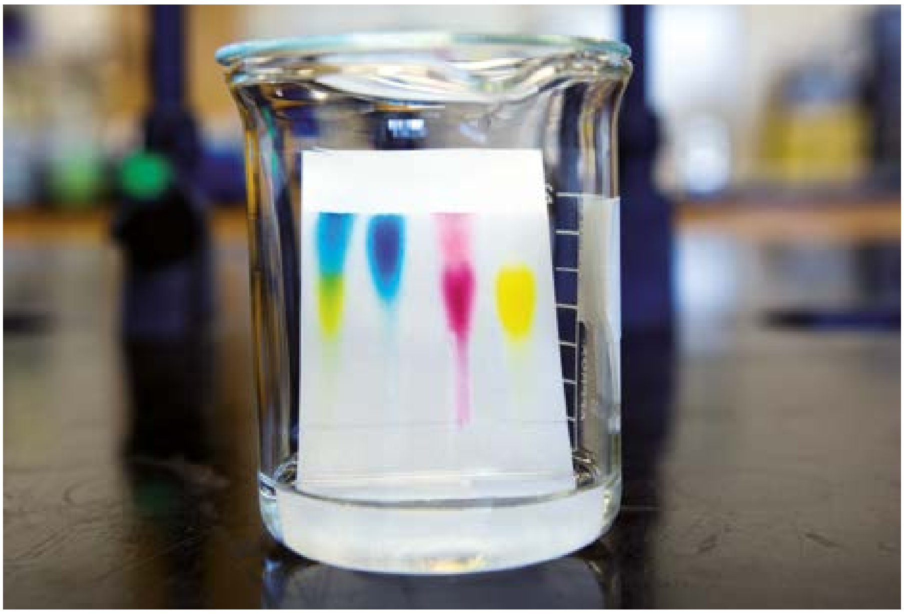
7.12 See section 7.3.2

7.4.3 Postgraduate degrees obtained

Table 7.13 illustrates the strong growth in taught postgraduate degree participation in engineering subjects, in terms of the number of degree qualifications obtained annually up to 2014/15. These numbers exclude students on integrated master's (MEng) courses, which are included in the first degree data. In the past ten years, total numbers have grown by over 68%. Between 2013/14 and 2014/15, total numbers grew by 15%. This is a return to levels last seen in 2010/11 and 2011/12, when many graduates entered postgraduate study to avoid immediate entry to a weak graduate labour market caused by the recession.

The increase in participation by students from outside the UK is notable. Numbers from outside the EU have more than doubled in ten years, while participation by EU and UK students has grown at broadly similar rates (ie by just over a third since 2004/05). The proportion of graduates from outside the UK has increased during this time, and is now around three quarters, showing the heavy reliance of taught postgraduate engineering provision on the international student market.

The proportion of female graduates has also risen during the ten-year period, from 19% in 2004/05 to 25% in 2014/15, and greater than the undergraduate population at large. This suggests that once they have obtained a first degree, a higher proportion of female engineering graduates than males progresses to studying a master's course.



Growth trends by sub-discipline are more varied. Table 7.14 shows the number of qualifications obtained in the last three academic years, and who obtained them in terms of gender and domicile. There has been consistent recent growth in civil, mechanical and aerospace engineering, but consistent smaller-scale decreases in electrical and electronic engineering, and production and manufacturing engineering. General engineering and chemical, process and energy engineering have had mixed fortunes year on year.

A quarter or more of these graduates were female in general, civil, production and manufacturing, and chemical, process and energy engineering, with this proportion broadly rising slightly over recent years. Although the proportions were lower for mechanical and aerospace, they too have been rising.

The proportion of international graduates participating varies between the sub-disciplines and has been rising in most. In particular, international participation in electrical and electronic engineering (nearly 86%), and production and manufacturing (just under 82%), was very high and continues to rise slightly. This suggests that it is likely that these courses would not be viable on the basis of UK interest alone.

Table 7.13: Taught postgraduate degrees achieved in engineering by domicile and gender (2004/5-2014/15) – UK

Postgraduate degrees		2004/05	2005/06	2006/07	2007/08	2008/09	2009/10	2010/11	2011/12	2012/13	2013/14	2014/15	Change over 1 year	Change over 10 years
Engineering	**Total**	**9,260**	**9,700**	**9,540**	**10,005**	**10,035**	**12,400**	**15,285**	**15,620**	**13,985**	**13,560**	**15,635**	**15.3%**	**68.8%**
	Female	1,780	1,865	1,735	1,880	1,790	2,140	2,775	2,945	2,950	3,000	3,890	29.6%	118.4%
	Male	7,480	7,835	7,805	8,125	8,245	10,260	12,510	12,675	11,035	10,560	11,745	11.2%	57.0%
	% Female	19.2%	19.2%	18.2%	18.8%	17.8%	17.3%	18.2%	18.9%	21.1%	22.1%	24.9%	2.8%p	5.6%p
	UK	2,960	2,860	2,760	2,815	2,925	3,170	4,030	3,900	3,655	3,365	3,965	17.8%	33.9%
	EU	1,735	1,665	1,755	1,550	1,420	1,670	2,105	2,235	2,170	2,175	2,355	8.3%	35.8%
	Non-EU	4,565	5,175	5,025	5,640	5,690	7,560	9,145	9,485	8,160	8,020	9,315	16.1%	104.0%
	Non-UK	6,300	6,840	6,780	7,190	7,110	9,230	11,250	11,720	10,330	10,195	11,670	14.5%	85.2%
	% Non-UK	68.0%	70.5%	71.1%	71.9%	70.9%	74.4%	73.6%	75.0%	73.9%	75.2%	74.6%	-0.6%p	6.6%p

Source: HESA bespoke data request

Table 7.14: Taught postgraduate degrees achieved in engineering subjects by domicile and gender (2012/13-2014/15) – UK

		2012/2013 (all domiciles)	2013/2014 (all domiciles)	2014/2015 (all domiciles)	Change over 1 year
General engineering	Total	1,840	1,630	1,735	6.5%
	Female	410	375	450	19.4%
	Male	1,430	1,255	1,290	2.6%
	% Female	22.3%	23.1%	25.8%	2.7%p
	UK	685	630	550	-12.5%
	EU	275	230	275	19.8%
	Non-EU	880	770	910	18.0%
	Non-UK	1,155	1,000	1,185	18.4%
	% Non-UK	62.8%	61.5%	68.2%	6.7%p
Civil engineering	**Total**	**3,145**	**3,090**	**3,295**	**6.6%**
	Female	855	885	950	7.3%
	Male	2,290	2,200	2,345	6.5%
	% Female	27.2%	28.7%	28.8%	0.1%p
	UK	1,050	900	915	1.5%
	EU	550	560	545	-2.6%
	Non-EU	1,545	1,630	1,835	12.6%
	Non-UK	2,095	2,190	2,380	8.7%
	% Non-UK	66.6%	70.9%	72.2%	1.3%p
Mechanical engineering	**Total**	**1,785**	**1,840**	**1,935**	**5.0%**
	Female	215	210	250	18.4%
	Male	1,570	1,630	1,685	3.3%
	% Female	11.9%	11.5%	12.9%	0.6%p
	UK	440	410	450	9.7%
	EU	335	340	350	2.8%
	Non-EU	1,005	1,090	1,135	4.0%
	Non-UK	1,345	1,435	1,485	3.3%
	% Non-UK	75.3%	77.8%	76.7%	-1.1%p
Aerospace engineering	**Total**	**655**	**760**	**810**	**6.6%**
	Female	80	110	130	16.2%
	Male	575	650	685	5.0%
	% Female	12.3%	14.3%	15.8%	1.5%p
	UK	130	170	170	0.9%
	EU	225	235	270	15.6%
	Non-EU	295	355	365	3.4%
	Non-UK	520	590	640	8.3%
	% Non-UK	79.9%	77.9%	78.8%	0.3%p
Electronic and electrical engineering	Total	3,645	3,250	3,195	-1.8%
	Female	705	705	690	-1.9%
	Male	2,940	4,795	2,500	-47.8%
	% Female	19.4%	21.7%	21.6%	-0.1%p
	UK	580	525	455	-12.9%
	EU	330	260	280	7.6%
	Non-EU	2,740	2,460	2,455	-0.2%
	Non-UK	3,065	2,725	2,735	0.4%
	% Non-UK	84.1%	83.8%	85.7%	1.9%p
Production and manufacturing engineering	**Total**	**1,170**	**1,095**	**1,090**	**-0.4%**
	Female	300	315	295	-6.0%
	Male	875	785	795	1.1%
	% Female	25.5%	28.6%	27.2%	-1.4%p
	UK	275	210	200	-4.4%
	EU	185	200	160	-21.2%
	Non-EU	710	690	730	6.1%
	Non-UK	895	890	890	0.0%
	% Non-UK	76.3%	80.9%	81.6%	0.7%p
Chemical, process and energy engineering	**Total**	**1,310**	**1,370**	**1,370**	**-0.1%**
	Female	335	370	370	-0.3%
	Male	975	1,000	1,000	0.0%
	% Female	25.5%	27.1%	27.0%	-0.1%p
	UK	320	340	355	4.1%
	EU	175	200	185	-6.4%
	Non-EU	810	830	825	-0.3%
	Non-UK	985	1,030	1,015	-1.5%
	% Non-UK	75.4%	75.2%	74.1%	-1.1%p

Source: HESA bespoke data request

Just under 3,000 doctorates were obtained in engineering and technology group subjects in 2014/15, a quarter of which (the largest proportion) were in electrical and electronic engineering. This is a somewhat different disciplinary balance from undergraduate or taught postgraduates. Table 7.15 shows the numbers of doctorates obtained for the last three years, by sub-discipline. Because the numbers are relatively small within sub-disciplines, there can be relatively large proportional changes year-on-year at sub-disciplinary level, so the annual change is not highlighted. However, the percentage of doctorates achieved by female candidates (around 23%) is typically higher than the proportion at first degree level (about 15%), as was the case for taught postgraduate study. The sub-disciplinary proportions by gender are broadly similar to lower level trends, with the highest proportion of female candidates in chemical, process and energy engineering and the lowest in mechanical and aerospace.

The proportion of doctorates obtained by international students in recent years has been high, at around 60% of all doctorates. It is especially high in electrical and electronic engineering, at around two thirds. Although international candidates comprise the majority in almost all the sub-disciplines in the years shown, the balance is less heavily towards international candidates than on taught postgraduate courses.

7.4.4 Non-continuation rates

A detailed analysis of first degree non-continuation rates, ie the proportion of students who left their degree programme without achieving a qualification, was published in last year's report. This showed that 5.6% of engineering students in the year graduating in 2013/14 did not complete their degree, very close to the proportion across all degree subjects of 5.3%. It found that the percentage amongst female students was somewhat lower than amongst males, and also some variation between different sub-disciplines. However, the higher rates tended to be in disciplines with greater gender imbalance, and the lowest in chemical, process and energy engineering (which has the highest proportion of female students), so these variations are likely to be related. As has been observed in other subjects, the non-continuation rate for those from backgrounds with a low participation rate in HE were somewhat higher than those from more advantaged backgrounds, and somewhat higher amongst those from state schools than independent. Data for the 2014/15 year is broadly similar to that from 2013/14, which was studied in detail. For that reason, it is not presented here.

Table 7.15: Doctorates achieved in engineering subjects by domicile and gender (2012/13-2014/15) – UK

Sub-disciplines		2012/2013 (all domiciles)	2013/2014 (all domiciles)	2014/2015 (all domiciles)
General engineering	**Total**	**540**	**585**	**595**
	% Female	20.1%	25.7%	20.9%
	% Non-UK	61.3%	55.9%	59.5%
Civil engineering	**Total**	**325**	**310**	**340**
	% Female	28.1%	29.4%	32.7%
	% Non-UK	60.6%	57.2%	58.2%
Mechanical engineering	**Total**	**440**	**390**	**435**
	% Female	13.8%	17.2%	17.4%
	% Non-UK	59.1%	58.2%	64.2%
Aerospace engineering	**Total**	**90**	**120**	**140**
	% Female	16.1%	14.6%	15.8%
	% Non-UK	47.6%	51.2%	64.1%
Electronic and electrical engineering	**Total**	**795**	**710**	**740**
	% Female	16.3%	19.0%	19.2%
	% Non-UK	66.6%	66.8%	67.4%
Production and manufacturing engineering	**Total**	**95**	**95**	**85**
	% Female	26.6%	29.6%	19.8%
	% Non-UK	54.2%	55.0%	59.7%
Chemical, process and energy engineering	**Total**	**250**	**305**	**325**
	% Female	39.4%	33.7%	32.5%
	% Non-UK	57.0%	62.5%	48.8%
Total engineering and technology	**Total**	**2,555**	**2,525**	**2,970**
	% Female	20.7%	23.5%	22.9%
	% Non-UK	61.3%	60.1%	59.9%

Source: HESA bespoke data request

7.5 Key factors underlying trends in higher education participation

7.5.1 Effect of population change upon HE participation

Population projections for young people in the UK pose a challenge to the future supply of highly skilled graduates into the engineering workforce. If they follow the current trajectory of entry to HE and transition into employment after graduation with a degree, we are facing an under-supply. Known and projected population data from the Office for National Statistics (Figure 7.6) suggest that the number of 18- to 20-year-olds is currently in decline and will fall by nearly 8% between 2017 and 2021, before beginning to rise again and increasing through to 2030.

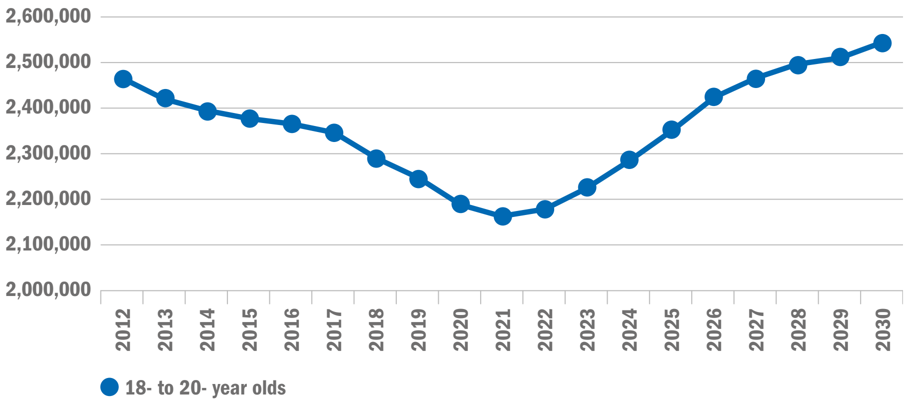
It should be noted that the population of 18-year olds in the UK unexpectedly increased slightly in 2015. Since this is the age group that dominates entry to undergraduate HE by UK students, the effect of this decline on entry to HE courses was somewhat hidden.

As our analysis in Chapter 10 shows, there is likely to be a continuing annual shortfall of supply of graduate level skills into the labour market in relation to anticipated demand. Therefore, it is important to examine whether and where there is potential capacity for growth in recruiting more students to engineering courses in HE. In the remainder of this section, we will examine how increasing and/or widening participation of currently under-represented groups of potential students, provision of part-time study, and the effect of participation by international students contribute to the supply of those with engineering degrees.

In fact, based on UCAS applicant data,[7.13] there will be some effect on overall participation in HE (not necessarily in engineering subjects) through the increasing proportion of young people that attends university. The proportion of the 18-year-old population in England who entered HE increased to 31.3% in 2015, 1% higher than the previous year and the highest recorded entry rate for England. When 19-year-olds are also taken into account, 42% of English young people had entered HE by age 19 in 2015; this was 1.5% higher than in 2014 and the highest rate recorded (and around a quarter higher than 2006 rates).

A slightly higher rise was seen in Wales (to 36% by age 19) in 2015. In Northern Ireland, there was a fall compared with 2014 (and re-approaching the 2006 level) but this is still at a higher level (43%) than for England or Wales. UCAS data for Scotland is less useful as a higher proportion of applicants does not use the UCAS system.

Figure 7.6: Numbers of 18- to 20-year-olds in the UK population (2012-2030)



Source: ONS

A related measure recorded by the DfE is the Higher Education Initial Participation Rate (HEIPR), which is an estimate of the likelihood of a young person participating in HE by the age of 30, based on current participation rates.[7.14] In 2014/15, this reached 48% for English-domiciled people, which was 1.7% higher than the previous year and significantly higher than the 42% recorded in 2006/07. The gradual overall increase in participation in HE by young people tends to offset the currently declining young population, but may not be sufficient to offset it completely, nor impact equally across all subjects. Therefore, its impact specifically on the engineering skills supply is unknown.

Although it is positioned further up the HE skills ladder, the Higher Education Funding Council for England (HEFCE) is currently funding a series of trials of engineering-related conversion courses at master's level.[7.15] This is being trialled as a possible means of increasing the number of graduates with postgraduate skills in engineering-related subjects, 'converting' graduates from other subjects to a potential engineering career pathway. Engineering master's courses have traditionally recruited some physics and mathematics graduates, in addition to graduates with engineering degrees. However, some of the pilot courses are targeting a wider range of STEM graduates, and in a few cases non-STEM graduates, provided that they have strong numeracy and some aptitude for engineering concepts. In principle, widening the first degree pipeline in this way could increase the flow of graduates with postgraduate level skills in engineering into the labour market.

7.5.2 Studying part-time and other HE models

One of the most striking changes in UK HE participation in recent years has been the decline in entry to part-time provision. As Figure 7.7 shows, the number of part-time first year enrolments to all HE courses (at all levels) has declined from 467,795 in 2009/10 to only 265,785 in 2014/15, which includes a fall of 5% in the last year.

In principle, part-time HE study has the capacity to increase the pool of potential HE-qualified employees in the labour force by enabling a wider range of learners through more flexible modes of study. The learner profile of part-time HE students is often different from those studying full-time, with many learners already in work – including those with existing qualifications who seek higher level study to develop particular knowledge and expertise to support their professional development. For the employer, part-time provision can enable its workforce to develop additional skills and knowledge while minimising the impact on the day-to-day business of releasing employees to full-time study.[7.16]

The decline in part-time HE provision also has a bearing on social mobility and overall HE participation as the socio-demographic characteristics of part-time students (both UK and EU) show that they tend to be older and are more likely to be female than their full-time peers. Many part-time students come from groups under-represented in HE, and the flexibility that part-time courses offer can provide an important second chance to pursue HE for those who might not have been able to go straight to university after school.

7.13 UCAS: *End of cycle report*, December 2015. https://www.ucas.com/sites/default/files/eoc-report-2015-v2.pdf **7.14** DfE: *Participation Rates In Higher Education: Academic Years 2006/2007 – 2014/2015* (Provisional, SFR45/2016), September 2016. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/552886/HEIPR_PUBLICATION_2014-15.pdf **7.15** HEFCE: *Engineering conversion course pilot scheme* (web page) http://www.hefce.ac.uk/kess/engineer/ **7.16** BIS: *A dual mandate for adult vocational education, a consultation paper*, March 2015. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/427342/bis-15-145-A-dual-mandate-for-adult-vocational-education.pdf

Back to Contents

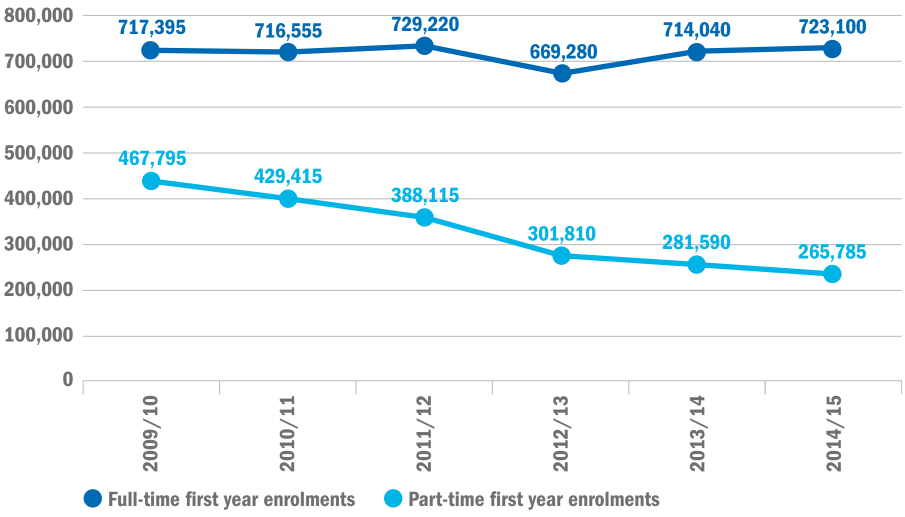
The reasons for the decline in part-time HE participation are thought to include:[7.17]

- Adjustments to the entitlement to funding for students studying for an equivalent or lower qualification (ELQ) in 2007/08;
- The recession and more general tightening of the budgets of employers (especially in the public sector);
- The substantial increases to tuition fees in 2012/13;
- Restrictions to eligibility to student loans for some types of part-time study.

In response to the rapid decline of part-time provision, and its potential impact on the upskilling of the workforce, the government announced in 2015 that more learners studying a part-time first degree in technology, engineering and computer science will be able to access tuition fee loans to retrain.[7.18] It has lately also announced a consultation on the potential introduction of maintenance loans to support those undertaking part-time HE study.[7.19]

The proportion of part-time students on engineering first degrees (92% in 2014/15, Table 7.4) is already amongst the highest of the STEM subjects and above the average across all subjects. It therefore seems unlikely that an increase in the supply of degree-qualified entrants to engineering will occur through increased amounts of part-time study. It is more likely that growth could come through qualifications other than first degrees (which are much more likely to be studied part-time), although the general trend is a decline in those types of qualifications in favour of full first degrees. The potential growth of Degree Apprenticeships could, however, redress this situation to some extent.

Figure 7.7: Numbers of first year enrolments by mode of study (2009/10-2014/15)



Source: HESA bespoke data request

Engineering Gateways: a work-based learning pathway to professional registration

Many engineers already in the workplace aspire to achieve an undergraduate or postgraduate degree and then professional registration without moving from employment to full-time study. Work-based learning pathways, through higher education and ultimately to professional registration, are valuable both to individuals and to employers who want to ensure their businesses have the skills they need for the future.

Engineering Gateways[7.20] is a flexible, work-based pathway to professional registration, aimed specifically at working engineers without the necessary full exemplifying academic qualifications. It is open to a broad range of engineers, with benefits identified by learners including:

- development of skills to succeed in work;
- guidance from both an academic and industry supervisor;
- study related to real work projects and problems;
- learning tailored to meet the needs of the individual and their job role;
- completion of a higher qualification whilst remaining in full time employment;
- achievement of Incorporated Engineer (IEng) or Chartered Engineer (CEng) status.

The programme is delivered through a learning contract approach between the employer, employee, university and professional engineering institution. Successful completion leads to the award of an appropriate academic qualification (master's or bachelor's degree) and demonstration (completed fully or partially alongside the degree) of the required competence for professional registration, as outlined in the UK Standard for Professional Engineering Competence (UK-SPEC). The candidate is thus eligible to apply for a professional review interview for Incorporated Engineer or Chartered Engineer status with a participating professional engineering institution.

Benefits identified by employers include:

- improved quality of work;
- staff bringing new ideas, methods and systems to the business informed by their learning;
- employees able to take on additional responsibilities;
- mechanism to draw out and recognise the latent talent;
- degree level study helps recent graduates cope with the responsibilities that they face increasingly early in their careers.

First developed in December 2006, the programme is now available in 10 universities and is supported by a number of professional engineering institutions. Over 250 individuals have achieved or are working towards professional registration as Incorporated or Chartered Engineers via the Engineering Gateways pathway.

With heightened interest in apprenticeships, this model could be used to enable those who have achieved EngTech or ICT Tech registration or completed an Advanced Apprenticeship to progress further in a work-based setting. This aligns with an original aspiration of the programme as a pathway professional registration for those following an Advanced Apprenticeship.

7.17 Bright Blue Campaign: *Going part-time: understanding and reversing the decline in part-time higher education*, 2015. http://www.brightblue.org.uk/images/goingparttimereport.pdf **7.18** BIS: *A dual mandate for adult vocational education, a consultation paper*, March 2015. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/427342/bis-15-145-A-dual-mandate-for-adult-vocational-education.pdf **7.19** DfE: *More support planned for part-time and doctoral degree students*, November 2016. https://www.gov.uk/government/news/more-support-planned-for-part-time-and-doctoral-degree-students **7.20** Engineering Council: *Engineering Gateways*. http://www.engc.org.uk/engineeringgateways

7.5.3 International students

Globally, the UK is the second most popular destination for internationally-mobile students. There has been substantial growth in participation in UK HE by international students since 2007/08, although that growth has tailed off since 2010/11. Following the UK's referendum decision to leave the EU, it is important to understand overseas student participation in UK HE, from both other EU countries and the rest of the world.

The earlier sections of this chapter on enrolments to the first year of undergraduate and postgraduate degree programmes, and data on qualifications obtained, show the relatively high proportion of engineering students that are from overseas. Nearly 30% of first degree students in their first year in 2014/15 were international (6.4% from EU nations and 22.6% outside the EU, Table 7.4). This is a higher proportion than for other STEM subjects and nearly double the proportion across all subjects. Based on data for those qualifying with first degrees (Table 7.10), the proportion of international students has fluctuated between 28% and 38% over the last ten years, and was just over 31% in 2014/15.

At taught postgraduate level, the student cohort is more international still, with over two thirds of 2014/15 entrants from overseas and 82% in electrical and electronic engineering (Tables 7.9 and 7.10). Amongst those achieving their taught postgraduate degrees, the pattern is similar, with the proportion of overseas graduates at around three quarters, and generally rising over the last ten years (Tables 7.13 and 7.14).

International students are of great importance both to the UK HE sector and to the country more widely. Economically, they are thought to contribute over £11 billion annually to the UK economy, of which over £3.7 billion is from EU students. Around half of this income is in the form of tuition fees and the remainder from their other expenditure while in the UK.[7.21] This tuition fee income represents over one eighth of the total income of the UK HE sector. However, their presence also adds crucial diversity to the academic environment and internationalises life on campus for UK students. With its highly international student body, engineering is certainly playing its part in this success.

However, in subject areas like engineering, where international students are in the majority, provision of taught courses at postgraduate level in particular has become heavily reliant on international student recruitment. Many of those courses could well become unsustainable without strong levels of international student participation. Without their presence, there could be knock-on effects for UK students who might not be able to participate in such courses and thereby develop the very high level skills needed for the UK engineering and technology sector. Stagnating or fluctuating demand from prospective international students can therefore leave institutions vulnerable or affect their ability to plan strategically for the longer term, and the engineering sector seems potentially more exposed to this than other subjects.

Although this is the subject of vigorous policy debate and contested opinion, recent government immigration policy may be having an impact on recent and future growth of international student recruitment to UK universities. Tightening of entitlement to post-study work opportunities and changes to requirements for non-EU students applying for subsequent work visas could be decreasing the attractiveness of the UK as a destination for internationally mobile students. If this is the case, for sectors like engineering, this will result in a loss of potential talent, as fewer highly-skilled graduates trained in the UK will be able to r emain here to work. Even if it is only a perception amongst prospective mobile students that the UK is less attractive, this is likely to reduce applications and subsequently income. There are suggestions that perceptions of this kind have had an impact on decreasing numbers of applications from certain countries, such as India, while there seems to have been less impact in other countries.

For example, the Engineering Professors' Council (EPC) 'Early Enrolments Survey' has recently shown that while there have been increases in non-EU student numbers on undergraduate engineering courses at Russell Group universities, more than one in three engineering departments in other types of university have recently experienced a drop in non-EU students. In both groups of universities, similar patterns were reflected in the numbers of non-EU postgraduate students. These were in contrast with the numbers of UK and EU students, which had risen in most cases. The EPC also notes that some departments have reported international students expressing concerns over whether the UK is still a welcoming destination for them, although competition from universities in other countries may also be a factor.[7.22]

Although it is too early to predict the impact of the UK's exit from the EU, it is possible that the current restrictions on non-EU students could potentially apply to a greater proportion of international students in UK HE in future.

What seems certain is that if the total number of international students does fall in the long term, the direct impact on the UK economy through decreased fees and expenditure will not be the only outcome. The contribution that these UK-trained overseas nationals could make to the UK labour force if they were entitled to, and chose to, enter it would also be reduced. With so many international students participating in engineering and technology courses, this is a potential issue for the supply of engineers to the UK economy. Although less likely than UK students to progress to employment in the UK after graduation, international students are major contributors to the engineering workforce. In the current political climate, and amid migration-related reforms, it seems unwise to suggest that future skills shortages in engineering could sustainably be countered through any increase in the contribution of international students. Although EU students are lower in proportion than those from the rest of the world, the UK's prospective departure from the EU could well exacerbate this situation.

7.21 Universities UK: *International higher education facts and figures*, June 2016, http://www.universitiesuk.ac.uk/blog/Pages/international-higher-education-in-facts-and-figures.aspx **7.22** Engineering Professors Council: *International engineering students becoming increasingly picky about UK universities, EPC survey reveals*, November 2016

7.5.4 Gender

Two key trends have been apparent for some years in relation to gender and study of engineering in HE. The first is the persistent under-representation of young women on engineering programmes, at all levels. Table 7.16 shows the proportion of engineering qualifications obtained by female students at first degree and other undergraduate, master's and doctoral levels across engineering subjects in 2014/15. There is variation between individual sub-disciplines, with the proportion of females highest in chemical, energy and process engineering and lowest in mechanical and aerospace. The data presented in Tables 7.11, 7.14 and 7.15 shows that these proportions have not changed substantially over the last few years (although there is greater variation year-on-year within individual disciplines at doctoral level as the number of graduates is much smaller).

Table 7.16 also shows that the proportion of females obtaining taught postgraduate and doctoral qualifications is higher than at first degree level. This reflects data in Chapter 8 which shows that a higher proportion of female first degree engineering graduates progresses to postgraduate study than males, whilst a lower proportion progresses directly into engineering employment. Again, this trend has not changed greatly in recent years.

A backdrop to these trends is the sustained increase in the total proportion of female HE students, and their higher academic attainment than male students. Overall, 57% of all first and postgraduate degree qualifications were obtained by women in 2014/15. This seems set to continue, based on the most recent application data from UCAS, as entry rates to HE increased three times faster for women than for men.[7.23] The entry rate for 18-year-old men did increase in 2015 but only by 0.4 percentage points, to 26.2%. The increase for women was 1.3 percentage points, taking the entry rate to 35.4%. Thus, for current 18-year-olds, young women are 35% more likely to enter HE than young men, which is the highest difference yet recorded. This equates to 36,000 fewer men entering HE in 2015 than would be the case if men had the same entry rate as women. Once 19-year-olds are also considered, the difference in entry rates between men and women widens by a further percentage point.

Table 7.16: Proportion of degrees obtained by females in engineering sub-disciplines, by level (2014/15) – all domiciles

	Foundation degree	Other undergraduate (not foundation)	First degree	Taught postgraduate	Doctorate
General engineering	11.4%	20.1%	16.9%	25.8%	20.9%
Civil engineering	17.2%	10.7%	16.2%	28.8%	32.7%
Mechanical engineering	6.8%	5.7%	8.2%	12.9%	17.4%
Aerospace engineering	5.8%	8.5%	10.7%	15.8%	15.8%
Electronic and electrical engineering	4.0%	7.1%	12.7%	21.6%	19.2%
Production and manufacturing engineering	1.8%	15.4%	19.5%	27.2%	19.8%
Chemical, process and energy engineering	21.7%	18.4%	27.6%	27.0%	32.5%
Engineering and technology total	9.2%	11.4%	15.1%	24.9%	22.9%

Source: HESA bespoke data request

This difference also seems to apply more strongly to those from disadvantaged groups. In the most disadvantaged areas in the UK, women at 18 years of age were 52% more likely to enter HE than men in 2015. This contributes to current concerns about the very low participation of white men from less advantaged backgrounds in HE, and a resultant policy focus on addressing this.[7.24] It is also notable that although men are well represented in vocational pathways and apprenticeships, they tend not to pursue these routes to levels that provide routes into HE.

In terms of attainment at degree level, HESA data show that 74% of female first degree graduates obtained a 'good' grade (ie a 2:1 grade or above) in 2014/15. This was higher than the proportion of male graduates who achieved high grades (69%).[7.25] Although this gap has narrowed slightly on 2013/14, it is clear that not only are female students outnumbering males in UK HE, but that they are also consistently outperforming them.

The under-representation of females in engineering HE study has persisted for many years, in spite of numerous efforts to increase it. However, their increasing dominance in HE participation and their high performance academically suggest that, in the longer term, they must remain a target as potential recruits to the engineering workforce.

7.23 UCAS: *End of cycle report*, December 2015. https://www.ucas.com/sites/default/files/eoc-report-2015-v2.pdf **7.24** Nick Hillman and Nicholas Robinson: *Boys to Men: The underachievement of young men in higher education – and how to start tackling it* (Higher Education Policy Institute Report 84), May 2016. http://www.hepi.ac.uk/2016/05/12/3317/ **7.25** HESA: *Students in higher education 2014/15*. https://www.hesa.ac.uk/data-and-analysis/publications/students-2014-15

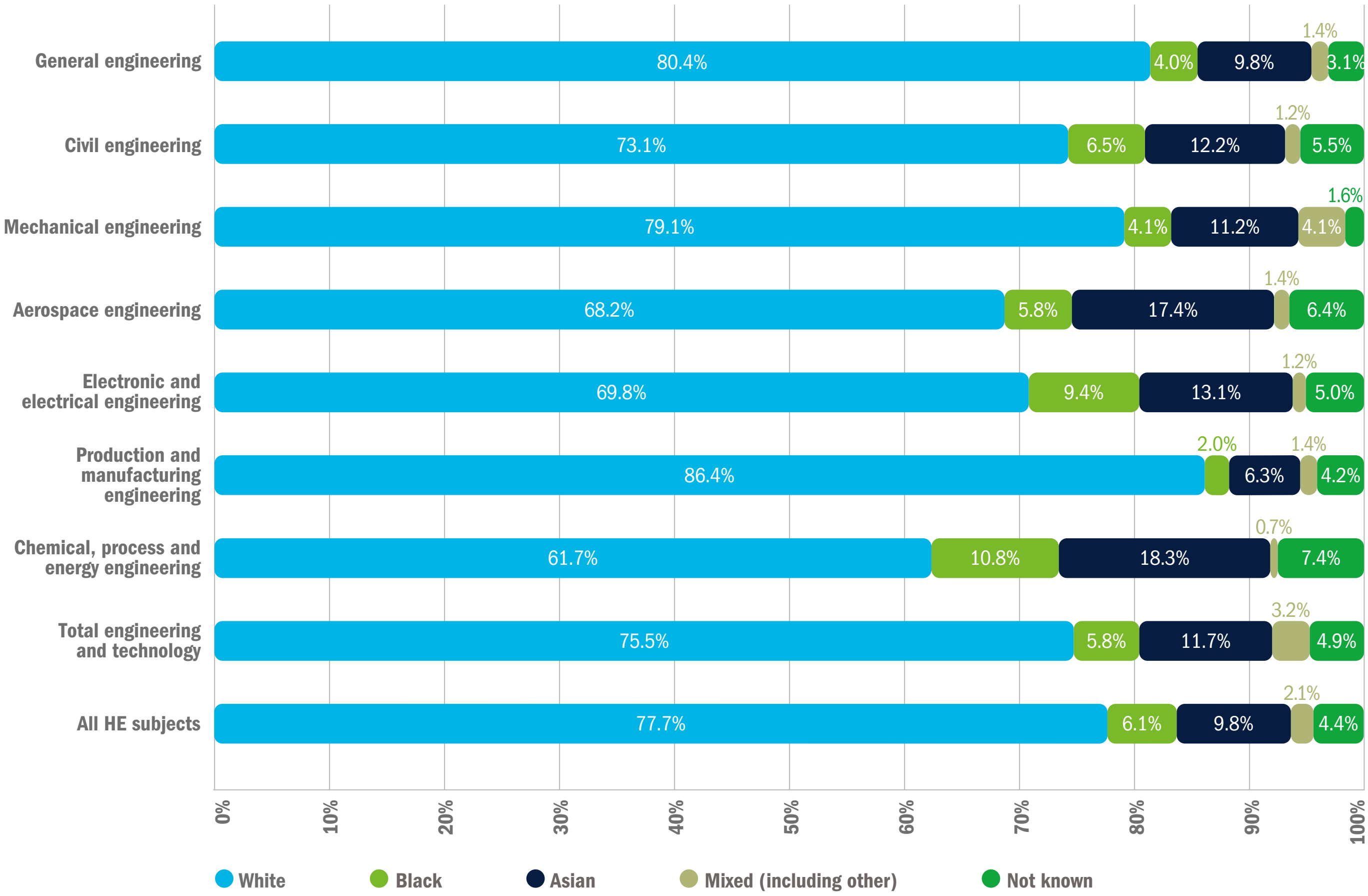
7.5.5 Ethnicity trends

In terms of the current mix of ethnic groups amongst UK students, engineering performs relatively well compared with other disciplines. Figure 7.8 illustrates that, in 2014/15, white students achieved 75.5% of first degrees in engineering in the UK, while other ethnic groups achieved 20%. This compares with an average across all subjects of 77.7% of first degrees being obtained by white students. Figure 7.8 also shows that amongst the engineering sub-disciplines, the most ethnically diverse discipline was chemical, process and energy engineering, with nearly 40% of first degrees being obtained by black and minority ethnic (BME) students. Electrical and electronic engineering was next, with over 30% BME students. There was a less diverse mix in production and manufacturing, mechanical and general engineering (all of which were less diverse than the graduating population as a whole).

Viewed over ten years, the proportion of UK students with BME backgrounds achieving first degrees in engineering has been increasing. In 2004/05, 79% of UK first degree engineering graduates were white and around 17% were of BME origin. By 2014/15, the proportion of BME graduates had risen to 21%. During this ten-year period, the proportions of graduating students of black, Asian and mixed and other ethnic backgrounds have all increased. The largest proportional increase (from a low base) was for black students, which nearly doubled to around 6%. This is broadly the same as the proportion of black students across all subjects.

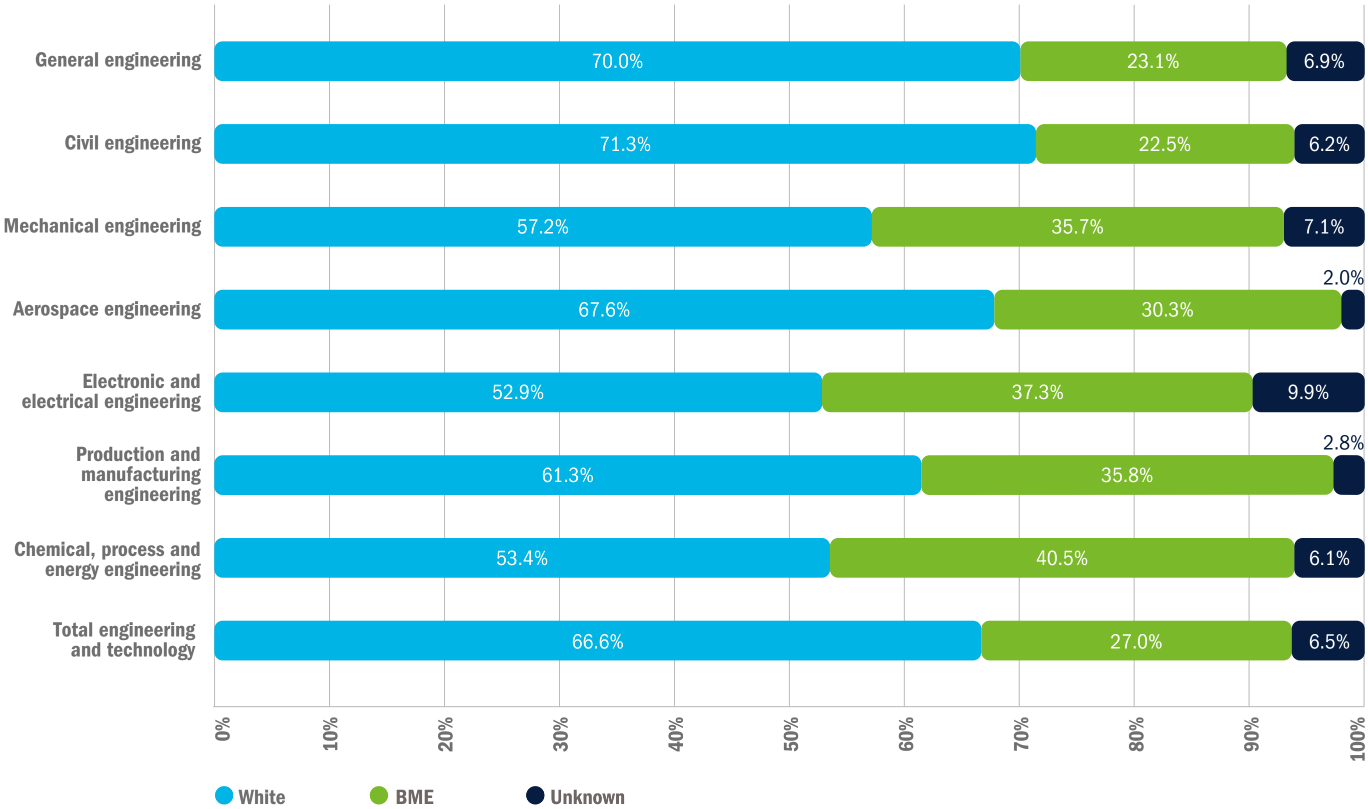
Numbers of UK-domiciled students of certain ethnic backgrounds on postgraduate taught courses within some engineering sub-disciplines are below the threshold for publication, so Figure 7.9 shows a simpler analysis by broad ethnic background. This shows that the ethnic profile of postgraduate taught courses differs from first degree courses, with a higher proportion of BME students. Overall, two thirds of students in 2014/15 were white and 27% were from BME backgrounds. The proportion of BME students was greater than one third in mechanical, electrical and electronic, and production and manufacturing engineering, and over 40% for chemical, process and energy engineering. As was the case for females when considering gender, this is evidence that students of ethnic minority background are quite strongly over-represented at postgraduate level. Differences

Figure 7.8: Proportion of first degrees obtained in engineering subjects by ethnicity (2014/15) – UK domiciles



Source: HESA bespoke data request

Figure 7.9: Taught postgraduate qualifications obtained in engineering subjects, by broad ethnic background (2014/15) – UK domiciles



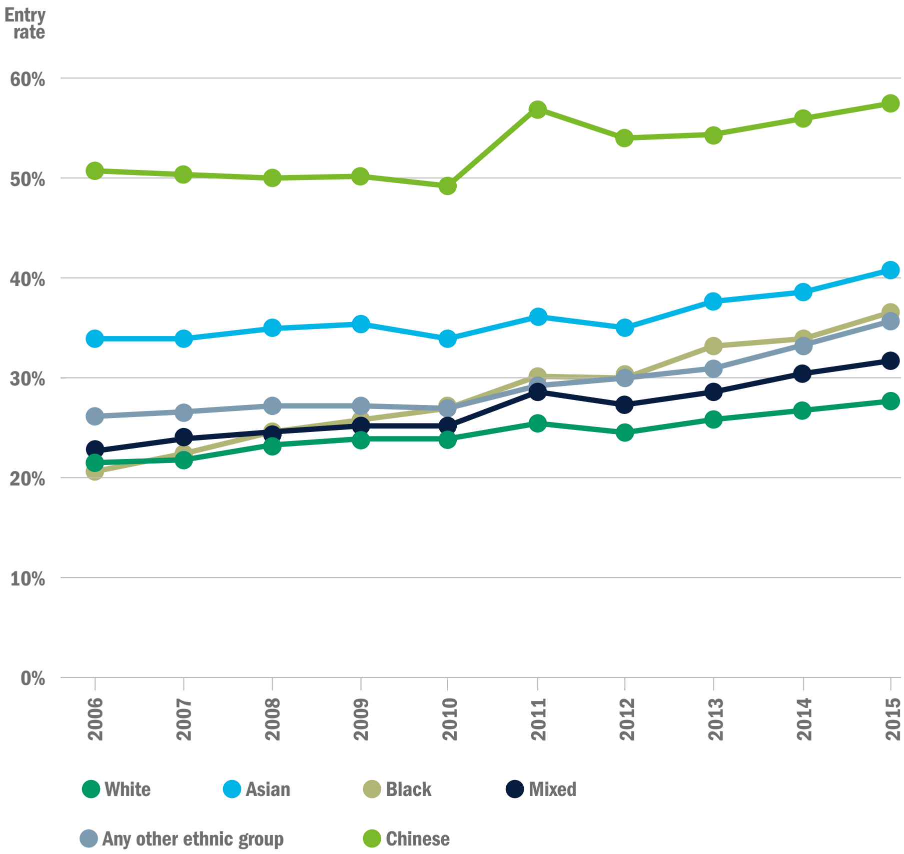
Source: HESA bespoke data request

in the ethnic profile of those progressing from first degrees into employment and those pursuing postgraduate study are also highlighted in Chapter 8 on engineering graduate destinations.

Given the relatively high propensity of UK graduates of ethnic minority background to pursue high-level study in engineering beyond first degree, there would seem to be benefit in increasing the supply that enter undergraduate study.

The government hopes to increase the number of young people from BME backgrounds attending university by 20% by the year 2020, which is equivalent to around 19,000 extra students.[7.26] Based on UCAS application data, there are signs that growth is being achieved (Figure 7.10). For example, the 2015 figures show that the entry rate for English 18-year-olds from state schools increased for all ethnic groups in 2015.[7.27] The entry rates for pupils from most ethnic groups lie in a range from 28% (white) to 41% (Asian), with pupils in the Chinese group highest at 58%. The largest

Figure 7.10: Entry rates for English 18-year-old state school pupils by ethnic group (2015)[7.28]



Source: UCAS

7.26 BIS: *Fulfilling our potential: teaching excellence, social mobility and student choice*, November 2015. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/474227/BIS-15-623-fulfilling-our-potential-teaching-excellence-social-mobility-and-student-choice.pdf
7.27 UCAS: *ibid* **7.28** UCAS: *ibid*

Back to Contents

increases in entry rates in 2015 (compared with 2014) were for pupils in the black group (up by 2.4% to 37%) and the Asian group (up 2.2% to 41%). The lowest increase was in the white ethnic group (up 0.6% to 28%).

The ethnicity profile of accepted UK applicants to engineering first degree courses has been diversifying in line with these broad trends. The proportion of accepted BME applicants has risen from around 24% to around 32% in the last seven years,[7.29] although only 29% of these actually commenced first degree courses in 2014/15 (Table 7.6). UCAS data back this up: it shows that the proportion of applications from students with BME backgrounds grew from around one quarter in 2007 to one third in 2015.[7.30] These figures all seem, encouragingly, to suggest that future cohorts of UK engineering students are likely to be increasingly ethnically diverse.

7.5.6 Socio-economic background

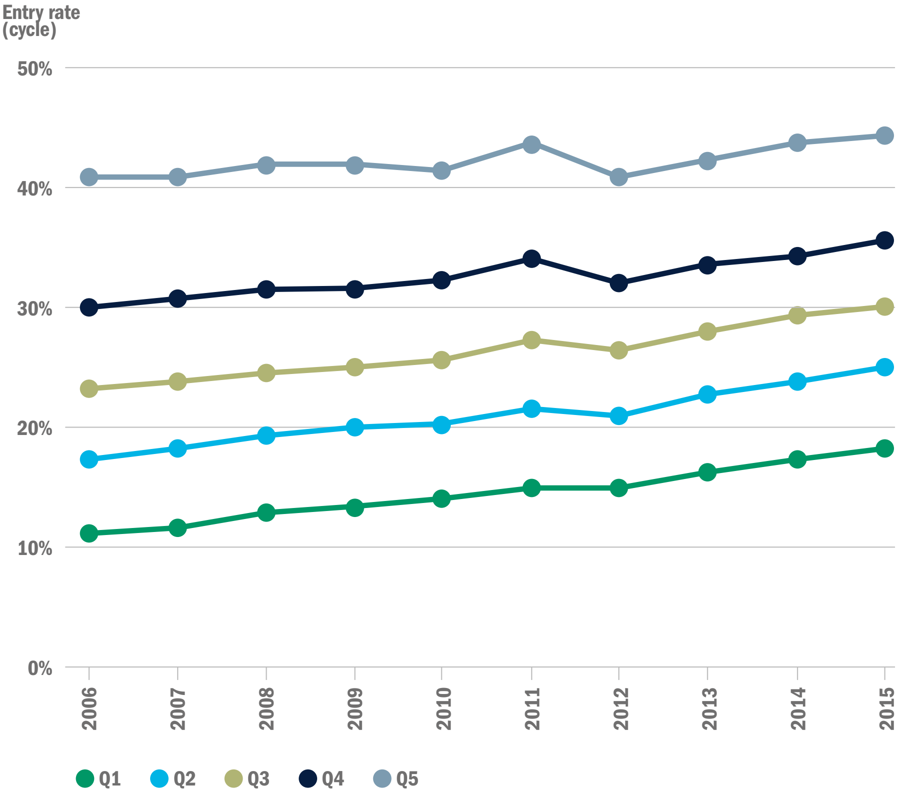
Social mobility is not only desirable for society but also closely linked to the wider performance of the economy: an OECD study warns that low social mobility can curb economic growth and constrain productivity. This implies that even from a narrow economic perspective, failure to tackle disadvantage and low aspirations could have a negative impact on the UK's economic wellbeing.[7.31] The government's higher education green paper[7.32] has set an ambitious target: it wants to double the proportion of pupils from disadvantaged backgrounds going into HE by 2020, from 2009/10's 13.6%. For this purpose, a 'disadvantaged' background refers to the neighbourhood where the young person lives, known as the POLAR3 measure; the government's ambition relates to young people living in the most deprived 20% of POLAR3 areas (called Quintile 1).

POLAR3

A key metric for measuring widening participation in HE is the participation of local areas (POLAR3) methodology. POLAR3 classifies local areas or 'wards' into five groups or 'quintiles', based on the proportion of young people who enter HE aged 18 or 19. These groups range from quintile 1 areas, with the lowest young participation (most disadvantaged), up to quintile 5 areas with the highest rates (most advantaged).

Figure 7.11 demonstrates that progress has been made over the last ten years in increasing the proportions of young people in England entering HE within all POLAR3 quintiles. The gap between the entry rate for those from areas with

Figure 7.11: Entry rate to higher education for 18-year-olds in England, by POLAR3 quintile (2006–2015)



Source: UCAS[7.33]

the highest participation level (quintile 5) and the lowest (quintile 1) is reducing slowly but remains large. The entry rate for the 2015 UCAS application cycle for 18-year-olds in quintile 1 in England increased by 0.7% to 18.5%. This is the highest level recorded, although the rate of growth was lower than in recent cycles. Nonetheless, on this basis, disadvantaged young people in England were 30% more likely to enter university in 2015 than five years ago, and 65% more likely than in 2006. Comparatively, advantaged 18-year-olds in England in 2015 (quintile 5) were 2.4 times more likely to enter HE than disadvantaged 18-year-olds (quintile 1). On the other hand, comparable entry rates in Wales and Northern Ireland decreased slightly in 2015, the first reductions recorded for this group since 2011.

UCAS has also begun to analyse entry rates using a range of equality dimensions in combination, such as ethnicity and whether pupils qualified for free school meals (FSM) as well as POLAR3 group. When this is done, entry rates can vary widely. For example, within POLAR3 quintile 3, young white men who received free school meals had an HE entry rate of just 9%, compared with the average for the POLAR3 quintile 3 group of 28%.

Lately, the under-representation of white young men from disadvantaged backgrounds, the group with the lowest participation in HE, has become a particularly source of concern and a focus for policy.[7.34] The latest participation data suggest that in 2014/15, the HEIPR (an estimate of the likelihood of a young person participating in HE by age 30) was 53% for English females – 10 percentage points more than the figure for males (43%) and a figure that had risen twice as fast during the past year.[7.35]

Based on these types of data, it is being suggested that the present trend in widening participation may not be sufficient to meet the government's ambition. The attainment gap between disadvantaged students and those from more advantaged backgrounds can be very large, and this may be partly underlying this issue. This is not something that most current outreach activities are designed to address, and begs the question of whether HE institutions should adjust their widening participation strategies to focus more on measures designed specifically to raise attainment at school. This is likely to apply as much to engineering courses as any other subject, given the requirements for prior achievement in STEM subjects and especially mathematics.

7.29 EngineeringUK: *The state of engineering 2016*, January 2016. http://www.engineeringuk.com/Research/ **7.30** UCAS: *ibid* **7.31** p30. Universities UK: *The economic role of UK universities*, June 2015, http://www.universitiesuk.ac.uk/policy-and-analysis/reports/Pages/the-economic-role-of-universities.aspx **7.32** BIS: *ibid, Fulfilling our potential: teaching excellence, social mobility and student choice*, November 2015. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/474227/BIS-15-623-fulfilling-our-potential-teaching-excellence-social-mobility-and-student-choice.pdf **7.33** UCAS: *ibid* **7.34** Sam Baars, Ellie Mulcahy and Eleanor Bernardes: *The underrepresentation of white working class boys in higher education: the role of widening participation*, 2016 (LKMco). https://www.lkmco.org/wp-content/uploads/2016/07/The-underrepresentation-of-white-working-class-boys-in-higher-education-baars-et-al-2016.pdf **7.35** DfE: *Participation Rates In Higher Education: Academic Years 2006/2007 – 2014/2015* (Provisional, SFR45/2016), September 2016. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/552886/HEIPR_PUBLICATION_2014-15.pdf

Part 3 - Engineering in Employment
8 Graduate destinations and recruitment

Key points

With the emergence of the UK economy from recession, graduates have continued to enjoy higher employment rates and earnings than those without a degree. UK universities all have strategies to maximise the employability of their graduates, but some concerns exist that although STEM graduates are in high demand, not all have a rounded set of both technical and transferable skills at the level that employers would ideally seek.

Employment prospects

UK first degree engineering graduates are more likely to be in full-time employment six months after graduation than the overall graduate population (68% had full-time jobs, compared with 58% of all graduates in 2014/15), although fewer enter part-time work or postgraduate study. This proportion has risen over the last five years, tracking the improvement in the economy, post-recession. Three years after graduation, 84% are in full-time work and only 2% unemployed.

Outcomes for those studying taught postgraduate engineering courses are more positive still, and again, more engineering postgraduates are in employment than the all-subject average.

Similar proportions of male and female engineering graduates enter full-time work six months after graduation. Relatively more females enter postgraduate study than males.

There is a larger variance with ethnicity in the employment outcomes of engineering graduates than amongst graduates overall: 71% of white engineering graduates are in full-time work within six months of graduation but only 51% of their counterparts of ethnic minority origin. Unemployment is more than twice as high amongst the latter. Why BME outcomes are relatively worse for engineering than other subjects merits investigation. Is this effect due to differences in the graduates themselves or the organisations recruiting them?

Destinations

Engineering graduates are highly likely to go on to a career in engineering: 71% of graduates who were in employment after graduating from a UK full-time first degree programme were working in an engineering occupation. This proportion was similar for both UK- and EU-domiciled graduates. The proportion was higher still amongst those who had studied part- time, peaking at 82% for civil engineering graduates.

There were variances with gender and ethnicity; a lower proportion of employed female engineering graduates (64%) than males (71%) were working in engineering occupations. These proportions were lower (58%) amongst employed engineering graduates of ethnic minority origin than for their white counterparts (73%). In some engineering sub-disciplines, the proportion of BME engineering graduates entering engineering occupations was less than half. The engineering sector needs to recruit evenly from across the talent pool if it is to optimise the supply of graduates into the workforce.

The proportions of engineering graduates entering sectors such as financial services or management consultancy were tiny in comparison with the proportions starting work as mechanical, civil or design engineers.

Graduates of other subjects contribute significantly to the engineering workforce. Roughly 1 in 8 of all employed first degree graduates works in an engineering occupation six months after graduation – around 11,000 engineering graduates and 14,000 from other disciplines.

Prospects and salaries

The graduate recruitment market has been buoyant in recent years but early signs post-referendum suggest a possible downturn. Recruiters may be shifting towards a greater emphasis on apprenticeships.

At just under £26,000 in 2014/15, engineering graduate starting salaries are well above the all-subject average and second only to medical and veterinary graduates. Postgraduate study adds a further premium.

Overall, there is no gender pay gap in the mean starting salaries earned by engineering graduates, although it does emerge in some sub-disciplines and there is evidence for a small ethnicity pay gap for engineering graduates. There are also significant variances in starting salaries based on the type of university attended – more so for engineering than other subjects. This may result from variances in occupational outcomes, as those entering occupations other than engineering earn less. More detailed analysis would be useful to determine the extent to which these earnings differences occur for those entering the engineering workforce.

8.1 Graduate employability

As the UK economy has continued its recovery from recession, employment prospects for new graduates have become increasingly promising. In the second quarter of 2016, the proportion of working age people (aged 16 to 64 years) reached a record high of 74.5%: a full percentage point higher than a year previously and well above the approximately 70% recorded five years ago. Furthermore, the Office for National Statistics has noted that the number of full-time jobs has been increasing faster than the number of part-time jobs.[8.1]

Graduates continue to enjoy higher employment rates than non-graduates and are more likely to work in highly skilled jobs than their non-graduate counterparts. In 2015, the employment rate amongst first degree graduates of working age was 87.1% (and fractionally higher amongst postgraduates), compared with 69.8% for non-graduates. Both these figures were slightly higher than comparable rates the previous year. What's more, the unemployment rate for graduates (3.1%) was less than half that for non-graduates (6.4%), although both are now below pre-recession levels.[8.2]

On the other hand, it has been reported that the earnings potential of degree holders differs little from that of apprentices. Research into careers starters and 25- to 29-year-olds across all subjects found little difference between the annual levels of pay between graduates and those with a level 3 apprenticeship.[8.3] Those completing a level 4 apprenticeship were thought to have a net lifetime earnings premium of around £118,000 (across all subject areas), which is very close to the premium currently calculated for a degree. (Graduates currently emerge with an average of around £44,000 of debt, and so the relatively high cost of their education which reduces their net earnings.)[8.4]

A falling unemployment rate can present something of a double-edged sword for the economy. A modest pool of unemployed but skilled individuals can be useful for employers as a source from which to recruit new staff for expansion or replacement. But if the unemployment rate becomes very low indeed, this slack in the labour market will tighten and employers may find it difficult to fill some vacancies.[8.5] Two thirds of the employers responding to the 2016 *CBI/Pearson Education and Skills Survey* feared that they would not be able to find enough workers with the required skills to fulfil their expected high-level skills needs. The year before, around half of survey respondents reported this concern, suggesting that these fears are intensifying. Demand for highly skilled workers was particularly strong in sectors critical to the rebalancing of the economy: over three quarters of employers in manufacturing and construction and 90% of those in engineering, science and high technology, expected their need for highly skilled staff to grow in the years ahead.[8.6]

In the past year, the government published two reviews into the employment outcomes of STEM graduates. The Wakeham review identified and focused on a number of STEM subject disciplines with relatively weak employment outcomes: in particular, biological sciences; earth, marine and environmental sciences; and agriculture, animal and food sciences.[8.7] In addition, it recommended that biomedical engineering, aerospace engineering and engineering design should, in future, be investigated in more depth to develop a clearer understanding of their graduate employment outcomes. The principal source of information used was HESA Destinations of Leavers from Higher Education (DLHE) data, which records graduate destinations six months after graduation. Wakeham reinforced the importance of graduates having had at least some work experience to build genuine employability, either through formal organised placements or informal mechanisms such as internships. It also presented evidence that employers continue to be dissatisfied with the level of graduates' 'soft' or 'work readiness' skills. Neither of these themes are new.

The second, the Shadbolt Review, considered computer sciences – a subject area that presents a mixed, and at times potentially contradictory, picture in terms of graduate employment outcomes.[8.8] Unemployment among computer sciences graduates (as recorded by the DLHE survey) has for some years been consistently higher than for other disciplines, despite shortages and strong demand for graduate-level skills in this area. Although not to the same degree, engineering suffers from similar problems, having a somewhat elevated rate of unemployment at the same time as graduate skills shortages.

Shadbolt notes that part of the raised unemployment rate is due to the particularly broad demographic profile of those who study computer sciences, some of whom tend to have weaker academic attainment. This breadth, and the profile of the HE institutions in which they study, has previously been identified as contributing to this apparent paradox.[8.9]

Like Wakeham, Shadbolt found that although many computer sciences graduates are well prepared for the transition to work, there is a swell of opinion in industry that suggests more could be done to improve their skills and work readiness. Some employers suggest graduates lack work experience, commercial awareness and other soft skills. On the other hand, Shadbolt notes that those employers who believed work experience was critical were only slightly more likely to offer work experience placements than others who did not value it much at all. He concluded that a clearer view of the skills that employers want is crucial, but right now there is no coherent voice from employers expressing what they are looking for in a STEM graduate. Therefore, it is important that we look ahead to the skills employers are likely to want in the coming years, particularly given the fast-paced nature of computer science and the speed of technological advancement and innovation.

One thing Shadbolt and Wakeham agreed on was that employers would like to see accreditation of HE courses to be more focused on outcomes and employability development, and not purely on technical knowledge:

It would benefit all stakeholders, including graduates, if employment outcomes, and employability, were to become a more central part of accrediting a degree programme. Accreditation should seek to support greater interaction between industry and HE, providing the mechanism to influence the design of degree programmes and an avenue for articulating the changing requirements of industry.

It seems likely that STEM graduates will continue to be in strong demand in the coming years. However, the first signs are emerging that the result of the UK referendum on the UK's membership of the European Union will impact on the graduate recruitment market. This chapter focuses on the most recent data on employment destinations of recent graduates, especially those with engineering degrees.

8.1 ONS: *statistical bulletin – UK labour market, September 2016*. http://www.ons.gov.uk/employmentandlabourmarket/peopleinwork/employmentandemployeetypes/bulletins/uklabourmarket/september2016 **8.2** BIS: *Graduate Labour Market Statistics: 2015*, April 2016. https://www.gov.uk/government/statistics/graduate-labour-market-statistics-2015 **8.3** Barclays and Cebr: *Productivity and lifetime earnings of apprentices and graduates*, August 2016. http://www.newsroom.barclays.co.uk/r/3385/apprentices_can_earn_up_to_270__more_over_their_lifetime **8.4** p4. The Sutton Trust: *Earning by Degrees – Differences in the career outcomes of UK graduates*, 2014. http://www.suttontrust.com/researcharchive/earningbydegrees/ **8.5** Cebr: *The benefits of apprenticeships to businesses* (A report for the Skills Funding Agency), March 2015. https://www.cebr.com/wp/wp-content/uploads/2015/03/The-Benefits-of-Apprenticeships-to-Businesses.pdf **8.6** CBI: *The right combination: CBI/Pearson Education and Skills Survey 2016*, July 2016. http://www.cbi.org.uk/news/getting-skills-right-more-vital-than-ever-post-referendum/ **8.7** BIS: *Wakeham Review of STEM Degree Provision and Graduate Employability*, 2016. https://www.gov.uk/government/publications/stem-degree-provision-and-graduate-employability-wakeham-review **8.8** BIS: *Shadbolt review of computer sciences degree accreditation and graduate employability*, 2016. https://www.gov.uk/government/publications/computer-science-degree-accreditation-and-graduate-employability-shadbolt-review **8.9** Council for Professor and Heads of Computing: *CS graduate unemployment report*, 2012. https://cphcuk.files.wordpress.com/2013/12/cs_graduate_unemployment_report.pdf

8.2 First destinations of graduates

The Higher Education Statistics Agency (HESA) undertakes the Destination of Leavers from Higher Education (DLHE) survey annually, which records the circumstances of UK and EU graduates an average of six months after they graduate. These survey results are extremely robust as response rates are up to 80% of the relevant target graduating population. Measures of graduate outcomes derived from the DLHE survey (such as the proportion entering employment or further study, or the proportion entering graduate-level employment) form part of the Key Information Set (KIS) of information provided for all undergraduate courses to prospective students, and also comprise a key performance indicator for HE institutions in relation to employability. HESA also undertakes a repeat survey of a sample of these graduates three years later (the 'Longitudinal-DLHE' or L-DLHE).

8.2.1 Destinations of first degree graduates

Table 8.1 shows the first destination (ie six months after graduation) for 2014/15 UK-domiciled first degree graduates who studied full-time. This is a particularly robust sub-group of graduates to analyse, as most UK graduates will want to work in the UK and it excludes part-time students who may already have been employed while studying. Where there is a gap in the data shown, this is because data are unavailable or grouping is smaller than the reporting threshold and requires suppression.

Across all subjects combined, 58% of graduates had entered full-time employment six months after graduating, 13% were working part-time, just over 18% were undertaking further study (some of whom were also working) and 5.7% were unemployed. The remaining 4.6% were unavailable for work for other reasons. In total, 76% were in employment of some kind. In comparison, a higher proportion of engineering and technology graduates entered full-time employment (67.6%), but fewer had entered part-time work or further study. In total, 78% were in employment. The unemployment rate amongst engineering and technology graduates was slightly higher (7.2%) than the all-subject average (5.7%).

Table 8.1: First destinations of full-time, first degree graduates from UK higher education institutions (2014/15) – UK domiciles

	Full-time work	Part-time work	Work and further study	Further study only	Unemployed	Other	Number
Medicine and dentistry	92.0%	1.0%	1.8%	4.6%	0.2%	0.5%	7,215
Subjects allied to medicine	77.0%	8.1%	3.6%	6.5%	2.3%	2.4%	25,330
Biological sciences	44.9%	15.7%	6.8%	21.8%	5.8%	5.1%	25,365
Veterinary science	90.4%	2.4%	1.5%	3.1%	0.5%	2.1%	580
Agriculture and related subjects	57.1%	12.1%	6.4%	10.2%	6.5%	7.8%	1,790
Physical sciences	44.3%	10.7%	4.6%	27.5%	7.7%	5.2%	11,640
Mathematical sciences	50.6%	7.2%	7.1%	22.4%	7.5%	5.3%	4,920
Computer science	66.4%	10.5%	2.3%	7.7%	10.0%	3.2%	8,895
Engineering & technology	65.4%	7.8%	3.0%	11.5%	7.7%	4.6%	12,065
Architecture, building and planning	70.2%	7.0%	5.3%	7.6%	5.9%	4.0%	4,030
Social studies	53.6%	13.1%	5.9%	14.8%	6.5%	6.1%	21,610
Law	40.7%	8.9%	10.9%	29.4%	5.3%	4.7%	8,690
Business and administrative studies	65.4%	10.7%	5.5%	6.7%	6.5%	5.1%	24,700
Mass communications and documentation	58.0%	20.6%	2.4%	6.2%	7.7%	5.1%	6,300
Languages	47.8%	14.1%	6.1%	20.0%	6.3%	5.7%	14,695
Historical and philosophical studies	43.5%	14.0%	6.6%	23.6%	6.5%	5.9%	10,545
Creative arts and design	51.9%	24.8%	3.4%	7.8%	7.1%	4.9%	25,025
Education	67.3%	11.9	3.0%	12.2%	2.3%	3.2	12,070
Combined total	46.4%	12.0%	9.6%	18.0%	6.0%	8.0%	410
Total – all subject areas	58.1%	12.8%	4.9%	13.8%	5.8%	4.6%	225,880

Source: HESA bespoke data request

Comparison with results for other subject groupings shows that engineering and technology graduates are some of the most likely to enter full-time employment, along with architecture, building and planning graduates and, most likely of all, medical and veterinary subjects graduates. In contrast, fewer than half of physical sciences or biological sciences graduates enter full-time employment after graduation, but much larger proportions progress onto postgraduate study.

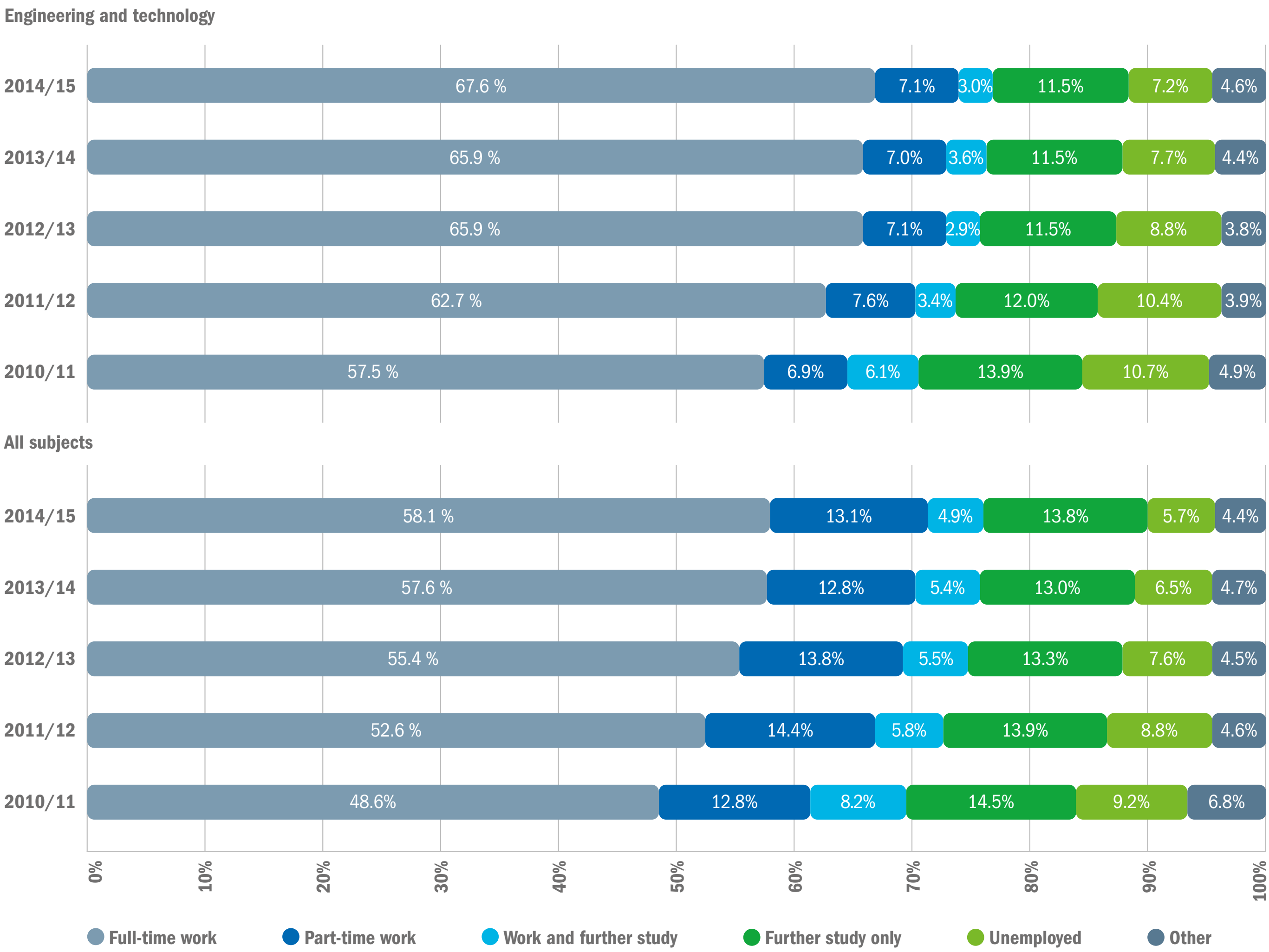
Comparable data for the previous five years is available in a report by the Royal Academy of Engineering.[8.10] From this, Figure 8.1 shows that the proportion of engineering and technology graduates entering full-time employment has risen annually for the past six years, and the proportion unemployed has fallen, as the UK economy has emerged from recession. A similar trend exists for all graduates combined, but with consistently lower rates of full-time employment. Interestingly, the proportion of graduates entering further study has declined over the period, which could well indicate that graduates were entering further study to avoid entering the labour market when it was particularly weak. Further results from that study are summarised in Section 8.5.

Table 8.2 shows how the destinations of first degree engineering graduates (rather than engineering and technology graduates), vary with their mode of study and domicile.

Just under 65% of those who studied full-time engineering courses were in full-time employment six months after graduation, compared with 84% of those who studied part-time. This elevated result is thought to reflect the fact that many of these graduates were combining part-time study with paid work that they continued after graduation. This theory is supported by the very low proportions of part-time students that were unemployed six months after graduation – just 3% – or who pursued further study full-time.

In terms of domicile, engineering graduates from outside the UK (ie other EU countries) were less likely to go into full-time work than graduates from within the UK (52% compared with 68%), but much more likely to enter further study than UK graduates (36% compared with 14%). The vast majority of these non UK graduates had studied full-time.

Figure 8.1: First destinations of full-time, first degree graduates (2010/11-2014/15) – UK domiciles



Source: Royal Academy of Engineering; HESA bespoke data request

8.10 Royal Academy of Engineering: *Employment outcomes of engineering graduates: Key factors and diversity characteristics*, November 2016. http://www.raeng.org.uk/eng-grad-destinations

When analysed by sub-discipline, civil engineering and production and manufacturing engineering graduates were more likely to enter full-time employment than the average for all engineering graduates (73% compared with 67%). General, mechanical, and electrical and electronic engineering graduates had a similar rate of full-time employment as the all-engineering-subject average. Aerospace engineering graduates and chemical, process and energy engineering graduates were less likely than the all-engineering average to have entered full-time employment (although their full-time employment rate was still higher than the average for all degree subjects combined). However, more of them entered further study and so their unemployment rate was only slightly higher than that of other sub-disciplines.

Table 8.2: First destinations of engineering subject first degree graduates, by mode and domicile (2014/15) – UK and other EU domiciles

	Full-time work	Part-time work	Work and further study	Further study only	Unemployed	Other	Number
General engineering	67.9%	4.9%	5.0%	12.4%	5.5%	4.4%	**1,365**
Full-time	62.0%	5.9%	4.3%	15.8%	6.6%	5.3%	1,050
Part-time	87.1%	1.6%	7.2%	0.9%	1.9%	1.3%	320
UK	69.6%	5.1%	4.9%	10.8%	5.3%	4.4%	1,255
Other EU	48.6%	2.7%	6.3%	29.7%	8.1%	4.5%	110
Civil engineering	72.7%	4.4%	4.0%	10.5%	4.9%	3.6%	**2,525**
Full-time	71.5%	4.4%	3.7%	11.4%	5.0%	4.0%	2,260
Part-time	82.8%	3.8%	6.5%	2.7%	3.4%	0.8%	260
UK	73.8%	4.6%	4.0%	9.1%	4.8%	3.7%	2,325
Other EU	59.5%	1.5%	4.0%	26.5%	5.5%	3.0%	200
Mechanical engineering	67.1%	5.9%	2.7%	11.8%	7.9%	4.5%	**4,095**
Full-time	65.5%	6.2%	2.4%	12.6%	8.4%	4.9%	3,720
Part-time	83.2%	2.4%	6.1%	4.0%	3.2%	1.1%	375
UK	68.6%	6.1%	2.7%	10.1%	7.8%	4.7%	3,815
Other EU	46.1%	3.6%	3.2%	35.0%	9.6%	2.5%	280
Aerospace engineering	58.9%	7.1%	4.3%	15.1%	8.8%	5.7%	**1,175**
Full-time	57.5%	7.4%	4.3%	16.0%	8.9%	6.0%	1,100
Part-time	80.0%	2.7%	5.3%	2.7%	8.0%	1.3%	75
UK	60.1%	7.4%	4.6%	12.9%	8.9%	6.1%	1,065
Other EU	47.8%	3.5%	2.6%	36.5%	7.8%	1.7%	115
Electronic and electrical engineering	66.7%	7.5%	3.0%	11.8%	7.8%	3.3%	**2,525**
Full-time	63.9%	8.2%	2.8%	13.0%	8.4%	3.6%	2,215
Part-time	85.7%	2.9%	4.1%	3.2%	3.2%	1.0%	315
UK	67.8%	7.9%	2.7%	9.7%	8.3%	3.5%	2,285
Non-UK	55.3%	4.1%	5.3%	31.6%	2.9%	0.8%	245
Production and manufacturing engineering	73.5%	6.6%	3.5%	7.0%	5.2%	4.3%	**515**
Full-time	68.8%	8.6%	2.0%	8.9%	6.3%	5.3%	395
Part-time	87.2%	0.8%	8.0%	1.6%	1.6%	0.8%	125
UK	73.9%	6.6%	3.6%	6.6%	5.0%	4.2%	500
Other EU	-	-	-	-	-	-	20
Chemical, process and energy engineering	59.0%	5.8%	3.0%	19.1%	9.8%	3.2%	**1,060**
Full-time	59.5%	6.0%	3.0%	18.9%	9.5%	3.2%	1,040
Part-time	-	-	-	-	-	-	20
UK	59.9%	6.1%	3.0%	18.3%	9.9%	2.9%	1,005
Other EU	43.6%	1.8%	3.6%	34.5%	7.3%	9.1%	55
Total in engineering	67.1%	5.9%	3.4%	12.3%	7.2%	4.1%	13,365
Full-time	64.9%	6.4%	3.1%	13.5%	7.7%	4.5%	11,835
Part-time	84.2%	2.2%	6.2%	3.0%	3.3%	1.0%	1,530
UK	68.4%	6.1%	3.4%	10.7%	7.2%	4.2%	12,330
Other EU	51.6%	3.0%	4.0%	31.9%	6.9%	2.7%	1,035
UK full time	66.1%	6.7%	3.0%	11.8%	7.7%	4.6%	10,830
All subjects	57.5%	12.9%	5.1%	14.0%	5.7%	4.9%	259,680
Full-time	57.4%	12.5%	5.0%	14.7%	5.9%	4.6%	237,420
Part-time	58.2%	16.9%	7.0%	5.8%	3.9%	8.3%	22,270
UK	58.1%	13.1%	5.1%	13.1%	5.7%	4.9%	247,825
Other EU	44.1%	7.1%	5.5%	32.5%	6.3%	4.5%	11,860

Source: HESA bespoke data request

8.2.2 Destinations of graduates by degree level

Table 8.3 looks at how a graduate's level of degree affected their first employment destination in 2014/15. It compares this information against employment destinations for all graduates, as well as examining the impact of mode of study and domicile. This information also helps us to understand the relative sizes of these different cohorts, including the modest numbers that study foundation degree or other undergraduate programmes in engineering.

At every degree level except 'other undergraduate', more engineering graduates than graduates of all subjects went on to full-time employment. Notably, more engineering students who studied at 'other undergraduate' level were unemployed than the all-subject average, although admittedly this was only a small cohort. Since numbers of respondents in certain groups in engineering were relatively small and fall below HESA's reporting threshold, the results for some response options have been suppressed in Table 8.3.

Postgraduates were more likely to secure full-time work than undergraduates: 74% of UK-domiciled taught postgraduates in engineering were in full-time employment six months after graduation, and 82% in employment of some kind. This figure was even higher for doctoral graduates, 86% of whom entered full-time employment (UK domiciled). It should be remembered, however, that the majority of students at these postgraduate levels in engineering are from outside the EU, and not covered by this DLHE survey.

Table 8.3: First destinations of engineering graduates, by level of degree (2014/15) – UK and other EU domiciles

	Full-time work	Part-time work	Work and further study	Further study only	Unemployed	Other	Number
Foundation degree							
Engineering	50.3%	1.7%	19.4%	25.9%	1.0%	1.7%	785
Full-time	48.9%	1.9%	9.7%	35.6%	1.7%	2.2%	360
Part-time	51.5%	1.4%	27.5%	17.8%	0.5%	1.3%	425
UK	50.6%	1.7%	19.8%	25.2%	1.0%	1.6%	770
Other EU	-	-	-	-	-	-	15
All subjects	31.9%	8.5%	21.1%	33.6%	2.4%	2.5%	11,935
Full-time	23.2%	7.8%	19.4%	44.8%	2.6%	2.3%	7,515
Part-time	46.6%	9.8%	24.0%	14.4%	2.1%	3.0%	4,420
UK	31.8%	8.6%	21.2%	33.4%	2.4%	2.5%	11,765
Other EU	33.9%	4.7%	9.9%	44.4%	4.1%	2.9%	170
Other undergraduate degree							
Engineering	44.4%	9.2%	4.9%	27.2%	11.0%	3.2%	525
Full-time	34.6%	9.9%	4.5%	34.9%	12.0%	4.0%	380
Part-time	69.5%	7.4%	5.8%	7.4%	8.5%	1.3%	150
UK	45.5%	9.2%	4.9%	25.8%	11.5%	3.0%	505
Other EU	-	-	-	-	-	-	20
All subjects	46.5%	13.7%	9.5%	19.5%	5.0%	5.8%	16,755
Full-time	37.7%	12.5%	5.6%	30.4%	8.3%	5.5%	7,090
Part-time	52.9%	14.6%	12.3%	11.5%	2.6%	6.0%	9,665
UK	47.0%	13.9%	9.5%	18.7%	5.1%	5.9%	16,255
Other EU	30.9%	7.2%	9.2%	46.3%	2.8%	3.6%	500
First degree							
Engineering	67.1%	5.9%	3.4%	12.3%	7.2%	4.1%	13,370
Full-time	64.8%	6.4%	3.1%	13.6%	7.7%	4.5%	11,845
Part-time	84.2%	2.3%	6.2%	3.0%	3.3%	1.0%	1,530
UK	68.3%	6.2%	3.4%	10.7%	7.2%	4.2%	12,335
Other EU	51.7%	2.9%	4.0%	31.9%	6.8%	2.7%	1,035
All subjects	57.5%	12.9%	5.1%	14.0%	5.7%	4.9%	259,690
Full-time	57.4%	12.5%	5.0%	14.7%	5.9%	4.6%	237,425
Part-time	58.2%	16.8%	7.0%	5.8%	3.9%	8.3%	22,265
UK	58.1%	13.1%	5.1%	13.1%	5.7%	4.9%	247,830
Other EU	44.1%	7.1%	5.5%	32.5%	6.3%	4.5%	11,860
Taught postgraduate degree							
Engineering	71.7%	4.2%	3.0%	9.4%	8.8%	2.9%	3,165
Full-time	65.5%	4.9%	2.9%	12.7%	11.0%	2.9%	2,220
Part-time	86.1%	2.5%	3.2%	1.8%	3.4%	3.0%	945
UK	73.8%	5.5%	2.6%	7.8%	7.7%	2.7%	2,040
Other EU	67.9%	2.0%	3.7%	12.4%	10.7%	3.4%	1,130
All subjects	66.6%	11.4%	4.9%	8.0%	5.1%	4.0%	72,170
Full-time	61.5%	11.2%	4.0%	11.6%	7.6%	4.0%	39,900
Part-time	72.8%	11.6%	6.1%	3.5%	2.0%	4.0%	32,265
UK	67.6%	12.0%	5.0%	7.1%	4.3%	4.0%	60,400
Other EU	61.3%	8.0%	4.6%	12.5%	9.5%	4.2%	11,765

Back to Contents

Table 8.3: continued

	Full-time work	Part-time work	Work and further study	Further study only	Unemployed	Other	Number
Doctorate							
Engineering	85.2%	3.7%	2.3%	2.5%	4.0%	2.4%	855
Full-time	86.0%	3.3%	1.9%	2.7%	4.2%	1.9%	760
Part-time	78.3%	6.9%	5.3%	1.1%	2.1%	6.4%	95
UK	85.8%	3.6%	2.0%	2.1%	4.2%	2.4%	630
Other EU	83.5%	4.0%	3.1%	3.7%	3.5%	2.2%	225
All subjects	75.4%	10.3%	3.1%	2.8%	4.1%	4.3%	9,325
Full-time	76.7%	9.5%	3.0%	3.0%	4.5%	3.3%	7,455
Part-time	70.3%	13.9%	3.4%	1.8%	2.5%	8.2%	1,870
UK	75.2%	10.8%	2.9%	2.6%	3.9%	4.6%	7,685
Other EU	76.8%	8.3%	3.8%	3.4%	5.0%	2.7%	1,635

Source: HESA bespoke data request

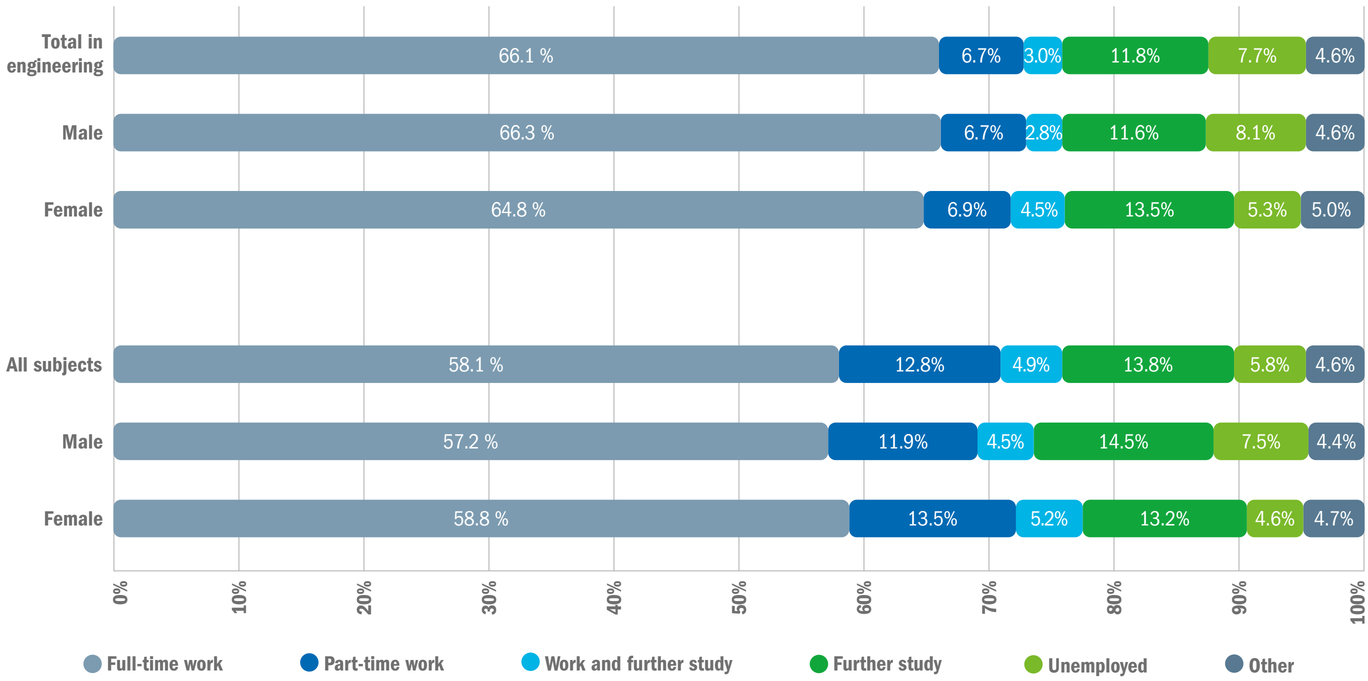
8.2.3 Variations in destinations of graduates with gender and ethnicity

In this section, we look at the gender and ethnicity of a 'core' group of UK-domiciled graduates who studied full-time for a first degree. (Including mode of study and other domiciles would result in significant variances, so we have removed these factors for clarity.) This group are the key potential new entrants to the UK labour market, and potentially to the engineering workforce.

Figure 8.2 shows that the outcomes for male and female first degree engineering graduates are very similar. A very slightly higher proportion of male engineering graduates than females entered full-time employment (66% male to 65% female), while it was the other way around for entry to further study (18% female to 14% male). There was also a lower rate of unemployment amongst females than males (5.3% to 8.1%).

There was a similar level of variance across all subjects. The difference was that slightly more – rather than slightly fewer – females than males entered full-time employment (59% female to 57% male), although the proportions for further study were essentially the same.
As with engineering graduates, males were more likely to be unemployed than females (7.5% against 4.6%).

Figure 8.2: Six month destinations of first degree graduates, by gender (2014/15) – UK domiciles, full-time study



Source: HESA bespoke data request

Figure 8.3 presents a similar analysis by ethnic background, again looking at UK graduates who studied full-time, first degree courses and graduated in 2014/15. Here there are marked differences. A much higher proportion of white engineering graduates entered full-time employment than those of ethnic minority background (71% white compared with 51% for all BME groups combined). Black graduates fared especially poorly, with only 48% gaining full-time employment. In contrast, the proportions of engineering graduates going into part-time work and further study were much higher for those of BME origin than for white engineering graduates.

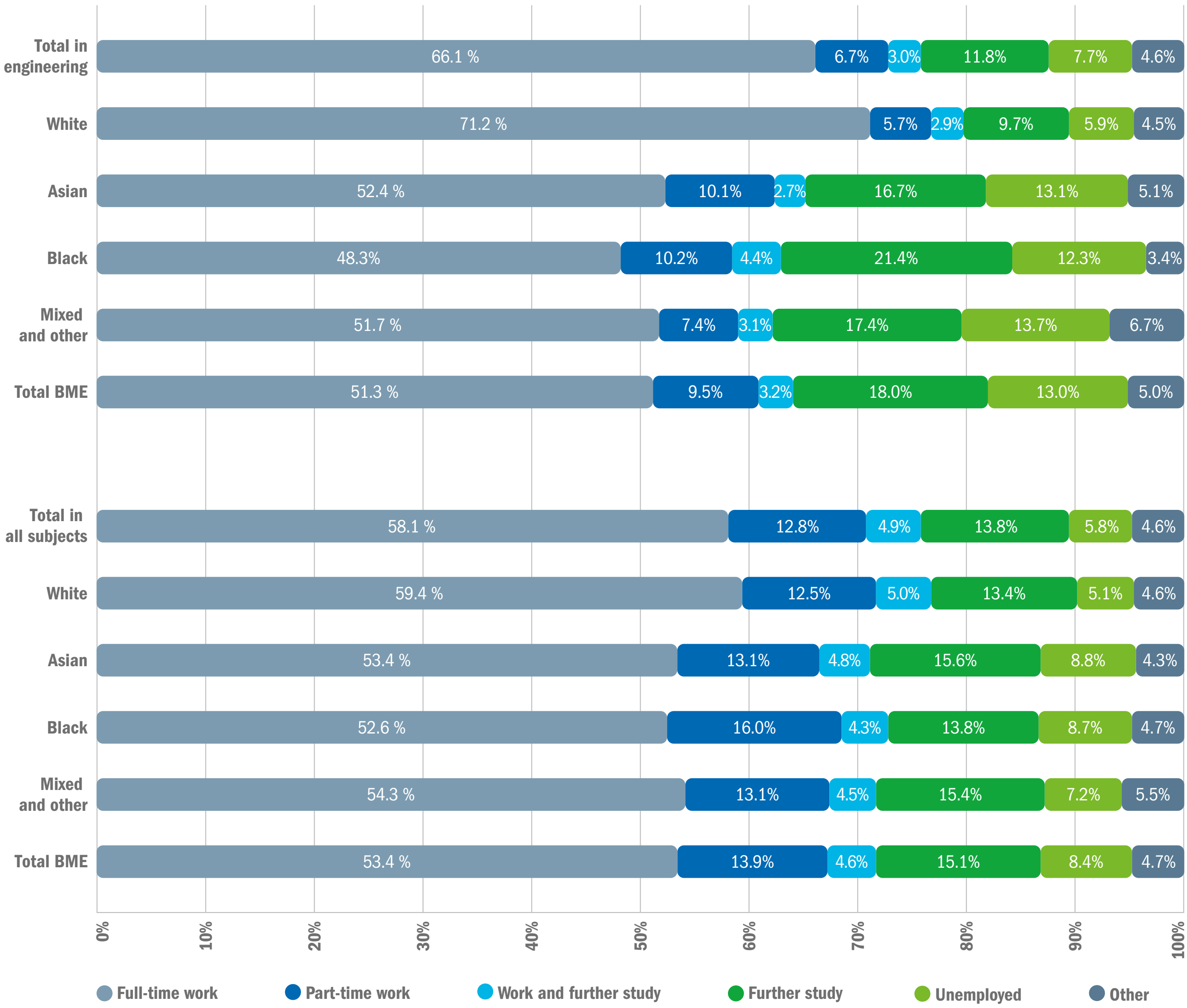
A sharp difference was also seen in the unemployment rate. This was 6% amongst white engineering graduates but more than twice this rate (13%) amongst those of ethnic minority origin.

What is also concerning is that although these trends mirrored those across all subjects, they were more pronounced among engineering graduates. For example, in the all-subject population, there was a 5 percentage point difference in the proportions of white and BME graduates who entered full-time employment. Among engineering graduates, that difference was much larger at 20 percentage points.

In parallel, the difference in the unemployment rate between white and ethnic minority graduates was greater for engineering graduates (7 percentage points) than for all subjects combined (3-4 percentage points).

Analysis for the Royal Academy of Engineering, described in Section 8.5, shows that these differences with ethnicity have been persistent in the DLHE results for the last five years. It also shows that the variances amongst engineering graduates have consistently been larger than for all graduates combined, although the gap has been narrowing. Nonetheless, these differences suggest the need for more investigation into why employment rates for engineering graduates of ethnic minority background differ from those of white engineering graduates, and why these differences are greater for engineering graduates than for all subjects combined.

Figure 8.3: Six month destinations of first degree graduates, by ethnicity (2014/15) – UK domiciles, full-time study



Source: HESA DLHE bespoke data request

8.3 Occupations of employed graduates

8.3.1 Engineering graduates

The data presented earlier in this chapter shows us how many graduates entered employment within six months of graduation – either full or part time – and how many of those continued their studies at the same time. The DLHE destinations data for 2014/15 tells us how many of these employed respondents were working in an engineering-related occupation (using EngineeringUK's Engineering Footprint).[8.11]

The results show that a clear majority of first degree and taught postgraduate engineering graduates were in an engineering occupation six months after graduation (Table 8.4). This was the case for 71% of first degree graduates, 67% of taught postgraduates, and 80% of foundation degree graduates, but only around half for other undergraduate programmes and doctorates.

At all levels except for doctoral graduates, more graduates who studied part-time were in an engineering occupation than those who studied full-time, reinforcing the assumption that many were already working in engineering before they began their part-time HE study.

It is also noteworthy that relatively similar proportions of UK and EU graduates went into engineering occupations. Whilst the UK is still a member of the European Union, EU citizens are fully eligible to seek employment in the UK, making EU-domiciled engineering graduates just as valuable as UK graduates as potential recruits to the UK engineering workforce.

Table 8.4: Proportion of employed engineering graduates in an engineering occupation, by level of degree (2014/15) – UK and other EU domiciles

	Engineering occupation	Non-engineering occupation	Total number in employment
Foundation degree	80.3%	19.7%	570
Full-time	68.2%	31.8%	215
Part-time	87.8%	12.2%	350
UK	80.4%	19.6%	560
Other EU	-	-	-
UK full-time	68.7%	31.3%	215
Other undergraduate degree	51.1%	48.9%	310
Full-time	41.1%	58.9%	185
Part-time	66.3%	33.7%	125
UK	51.7%	48.3%	300
Other EU	-	-	-
UK full-time	41.7%	58.3%	180
First degree	71.4%	28.6%	10,255
Full-time	69.5%	30.5%	8,840
Part-time	83.0%	17.0%	1,415
UK	71.4%	28.6%	9,645
Other EU	70.3%	29.7%	605
UK full-time	69.4%	30.6%	8,255
Taught postgraduate degree	67.1%	32.9%	2,500
Full-time	65.0%	35.0%	1,630
Part-time	70.9%	29.1%	870
UK	65.3%	34.7%	1,670
Other EU	70.8%	29.2%	830
UK full-time	60.4%	39.6%	900
Doctorate	46.5%	53.5%	785
Full-time	47.0%	53.0%	695
Part-time	42.1%	57.9%	85
UK	46.0%	54.0%	580
Other EU	47.8%	52.2%	205
UK full-time	46.3%	53.7%	520

Source: HESA bespoke data request

8.11 A full copy of the footprint is included in the Annex to this report 8.15 ns indicates results below the HESA threshold for reporting

Just over 69% of those who went into employment – based on UK-domiciled engineering graduates who studied full-time – chose an engineering occupation. Table 8.5 breaks this down by sub-discipline. Civil engineering graduates were the biggest contributors, with almost 82% entering engineering occupations, followed by mechanical engineering at over 70%. Aerospace and general engineering contributed fewer than average graduates to the engineering workforce, at around 59%. Lowest of all was production and manufacturing engineering, at 54%.

Notably, there were significant differences between the number of female engineering graduates entering engineering occupations and the number of males (Table 8.6). Overall, 71% of employed males were working in engineering occupations compared with 64% of females. The difference was largest (over 20 percentage points) for electrical and electronic engineering and production and manufacturing engineering (17 percentage points). Less than half of employed females went into engineering occupations in these two groups, despite production and manufacturing engineering having the highest employment rate (74%, Table 8.2). The differential was also significant for most other sub-disciplines. Only civil engineering, and chemical, process and energy engineering, saw a higher proportion of employed females than males in engineering occupations. The latter could be seen as a success story in terms of female entry to engineering employment, as this is also the sub-discipline with the highest proportion of female student participation.

Table 8.5: Proportion of employed engineering graduates working in an engineering occupation six months after graduation, by sub-discipline – (2014/15) – UK domiciles, full-time study

	Engineering occupation	Non-engineering occupation	Total number in employment
General engineering	59.2%	40.8%	705
Civil engineering	81.8%	18.2%	1,680
Mechanical engineering	71.9%	28.1%	2,630
Aerospace engineering	58.6%	41.4%	710
Electronic and electrical engineering	66.5%	33.5%	1,510
Production and manufacturing engineering	53.7%	46.3%	300
Chemical, process and energy engineering	64.8%	35.2%	690
Total engineering	69.4%	30.6%	8,255

Source: HESA bespoke data request

Table 8.6: Proportion of employed engineering graduates working in an engineering occupation six months after graduation, by sub-discipline and gender – (2014/15) – UK domiciles, full-time study

	Engineering occupation	Non-engineering occupation	Total number in employment
General engineering	59.9%	40.1%	695
Male	62.1%	37.9%	555
Female	50.8%	49.2%	140
Civil engineering	82.0%	18.0%	1,675
Male	81.2%	18.8%	1,425
Female	86.5%	13.5%	250
Mechanical engineering	72.2%	27.8%	2,615
Male	72.6%	27.4%	2,420
Female	67.3%	32.7%	195
Aerospace engineering	59.1%	40.9%	700
Male	60.1%	39.9%	625
Female	51.4%	48.6%	75
Electronic and electrical engineering	66.8%	33.2%	1,505
Male	69.0%	31.0%	1,340
Female	48.6%	51.4%	165
Production and manufacturing engineering	53.7%	46.3%	300
Male	57.7%	42.3%	230
Female	40.6%	59.4%	70
Chemical, process and energy engineering	65.0%	35.0%	685
Male	64.4%	35.6%	520
Female	66.8%	33.2%	165
Total engineering	69.7%	30.3%	8,210
Male	70.6%	29.4%	7,140
Female	64.0%	36.0%	1,070

Source: HESA bespoke data request

Examining the data by ethnicity reveals a consistent pattern. Across all disciplines, 73% of white engineering graduates in employment were in an engineering occupation, while this was significantly lower (58%) for those of BME origin, and slightly lower still (56%) for those of black origin.

By sub-discipline, the size of many groups is very small, so the analysis is presented in terms of white origin and a broader grouping of all those of black and minority ethnic (BME) origin combined. For every engineering sub-discipline, the proportion of white employed graduates working in an engineering occupation was significantly higher than the comparable proportion of employed BME graduates. For some sub-disciplines, there was a difference of more than 20 percentage points (notably aerospace and mechanical engineering). Even general engineering and electrical and electronic engineering had more than a 5 percentage point difference. The small size of the BME group within production and manufacturing engineering graduates in employment is too small to be reported, but the proportion in engineering occupations is again clearly lower than their white counterparts.

In summary, a clear pattern has unfolded: nearly half of female engineering graduates and those of ethnic minority background who are entering employment after university are not going into engineering occupations. These are larger proportions than amongst male engineering graduates and those of ethnic minority background, respectively. These marked differences with gender and ethnicity surely merit investigation, whether they arise from engineering graduates' desired career intentions or are due to factors in the recruitment process. Either way, this is a substantial loss to the pipeline of engineering skills.

Table 8.7: Proportion of employed engineering graduates working in an engineering occupation six months after graduation, by sub-discipline and broad ethnic group (2014/15) – UK domiciles, full-time study

	Engineering occupation	Non-engineering occupation	Total number in employment
General engineering	59.9%	40.1%	695
White	61.4%	38.6%	565
BME	53.0%	47.0%	130
Civil engineering	82.0%	18.0%	1,675
White	85.1%	14.9%	1,280
BME	72.0%	28.0%	375
Mechanical engineering	72.2%	27.8%	2,615
White	75.4%	24.6%	2,190
BME	54.9%	45.1%	410
Aerospace engineering	59.1%	40.9%	700
White	65.1%	34.9%	515
BME	42.0%	58.0%	180
Electronic and electrical engineering	66.8%	33.2%	1,505
White	68.1%	31.9%	1,110
BME	63.5%	36.5%	385
Production and manufacturing engineering	53.7%	46.3%	300
White	55.8%	44.2%	260
BME	41.2%	58.8%	40
Chemical, process and energy engineering	65.0%	35.0%	685
White	70.5%	29.5%	485
BME	51.2%	48.8%	195
Total engineering	69.7%	30.3%	8,210
Asian	58.7%	41.3%	990
Black	56.3%	43.7%	395
Mixed, other	59.9%	40.1%	335
White	72.8%	27.2%	6,430
Total BME	58.4%	41.6%	1,715

Source: HESA bespoke data request

Table 8.8 shows the top ten engineering occupations, and non-engineering occupations, entered by employed engineering and technology graduates six months after graduation in 2014/15. The proportions entering different occupations to some extent depends on how specific the occupational definition is. However, it is safe to say that more than 10% of employed engineering graduates became civil engineers and mechanical engineers, making these the most common engineering-specific occupations. Around 1% entered the financial sector as analysts or management consultants – well below the proportion entering engineering professional roles.

At first glance it may seem concerning that, for example, more employed graduates went into retail than electrical or electronic engineering. However, this in not necessarily evidence of graduate under-employment. The DLHE survey is conducted around six months after graduation, and there is evidence that a growing number of new graduates defer choices about their long-term 'career job' until some time after they have graduated. So the employment they enter immediately after graduation may well be temporary while they consider their longer-term choices.

Table 8.8: Most popular engineering and non-engineering occupations for engineering graduates, shown as a percentage of total employed engineering graduates (2014/15) – UK domiciles, full-time study

Most popular engineering occupations		Most popular non-engineering occupations	
Civil engineers	14.1%	Sales and retail assistants	3.1%
Mechanical engineers	12.0%	Business and related associate professionals n.e.c.	1.5%
Design and development engineers	9.3%	Bar staff	1.2%
Engineering professionals n.e.c.	8.8%	Management consultants and business analysts	1.2%
Production and process engineers	4.7%	Finance and investment analysts and advisers	1.0%
Programmers and software development professionals	3.3%	Business and financial project management professionals	0.9%
Electrical engineers	2.5%	Business sales executives	0.8%
Electronics engineers	2.0%	Customer service occupations n.e.c.	0.8%
Engineering technicians	1.5%	Officers in armed forces	0.7%
IT business analysts, architects and systems designers	1.2%	Other administrative occupations n.e.c.	0.7%

Source: HESA bespoke data request

8.3.2 Other graduates

Detailed analysis of the employment destinations of graduates of subjects other than engineering is clearly beyond the scope of this publication. However, it is important to note that some do enter engineering occupations, adding an extra element to the engineering workforce supply chain. Table 8.9 shows both the number of first degree graduates from each of the major subject groupings who were in employment six months after graduation, and the proportion that were working in engineering occupations. The figures are further broken down into UK-domiciled graduates and those of UK origin who studied full time (the group most likely to be new entrants to the labour force). Figures for the engineering and technology subject grouping are included for comparison, and are within the total figures at the foot of the table.

This analysis shows that 13% (just over one in eight) of all employed first degree graduates were working in an engineering occupation six months after graduation, based on the SOCs listed in EngineeringUK Engineering Footprint. Numerically, this was over 25,000 graduates, 11,305 of whom came from the engineering and technology subject grouping. So more half of the graduates entering engineering occupations did not have engineering degrees. The contribution of these other graduates to the potential supply of graduate-level skills in the engineering labour force is reconsidered in Chapter 10.

It is worth highlighting the significant contribution to the engineering workforce made by employed graduates from computer science, architecture, and building and planning, more than half of whom entered an engineering occupation. In fact a higher proportion of employed graduates from architecture, building and planning went into engineering occupations than of engineering and technology graduates.

Table 8.9: Proportion of employed first degree graduates working in engineering occupations six months after graduation, by major subject group (2014/15) – UK and EU domiciles, full-time study

	Engineering occupation	Non-engineering occupation	Total number in employment
Medicine and dentistry total	0.5%	99.5%	7,010
UK	0.5%	99.5%	6,855
UK full-time	0.4%	99.6%	6,835
Subjects allied to medicine	2.1%	97.9%	26,310
UK	2.1%	97.9%	25,690
UK full-time	2.2%	97.8%	22,465
Biological sciences	6.9%	93.1%	19,005
UK	6.9%	93.1%	1,855
UK full-time	6.8%	93.2%	17,065
Agriculture and related subjects	14.8%	85.2%	1,455
UK	14.8%	85.2%	1,415
UK full-time	15.1%	84.9%	1,355
Physical sciences	21.0%	79.0%	7,505
UK	20.9%	79.1%	7,380
UK full-time	20.8%	79.2%	6,935
Mathematical sciences	16.1%	83.9%	3,535
UK	15.8%	84.2%	3,450
UK full-time	14.9%	85.1%	3,185
Computer science	58.4%	41.6%	8,095
UK	57.7%	42.3%	7,660
UK full-time	58.2%	41.8%	7,025
Engineering and technology	67.2%	32.8%	11,305
UK	67.2%	32.8%	10,650
UK full-time	64.9%	35.1%	9,180
Architecture, building and planning	76.5%	23.5%	4,420
UK	75.8%	24.2%	4,165
UK full-time	74.8%	25.2%	3,320
Social studies	3.3%	96.7%	18,125
UK	3.2%	96.8%	17,515
UK full-time	3.2%	96.8%	15,655
Law	2.8%	97.2%	5,990
UK	2.9%	97.1%	5,780
UK full-time	2.5%	97.5%	5,255
Business and administrative studies	5.2%	94.8%	23,695
UK	5.2%	94.8%	22,145
UK full-time	4.4%	95.6%	20,130
Mass communications and documentation	3.8%	96.2%	5,500
UK	3.8%	96.2%	5,225
UK full-time	3.8%	96.2%	5,100
Languages	21.6%	78.4%	1,335
UK	2.6%	97.4%	10,650
UK full-time	2.3%	97.7%	9,970
Historical and philosophical studies	3.6%	96.4%	7,655
UK	3.6%	96.4%	7,555
UK full-time	3.0%	97.0%	6,740
Creative arts and design	12.8%	87.2%	21,315
UK	12.7%	87.3%	20,525
UK full-time	12.7%	87.3%	20,040
Education	0.6%	99.4%	11,560
UK	0.6%	99.4%	11,610
UK full-time	0.5%	99.5%	9,955
Total – All subject areas	13.2%	86.8%	195,695
UK	12.9%	87.1%	188,985
UK full-time	12.3%	87.7%	170,985

Source: HESA bespoke data request

8.4 Industry sectors entered

Standard Industrial Classification (SIC) codes identify the primary industrial focus or sector of an employer, and therefore give an indication of which sector graduates have entered six months after graduation. It is worth noting that the specific occupational role of an employee can be quite different from the primary activity of their employer. It is possible for a graduate to be working in an engineering role for an organisation which is not in the engineering sector, or for them to work in a non-engineering role in an engineering employer (although this is perhaps rarer given the relatively broad occupational footprint adopted by EngineeringUK).

This section aims to clarify the extent to which engineering graduates went to work in the engineering sector rather than any other. The analysis is based on graduates' responses to the DLHE survey about the business of their employer, which has been matched to SIC codes by HESA. The robustness of this data therefore relies on how accurately the graduate employees understood and described their employers' business.[8.12]

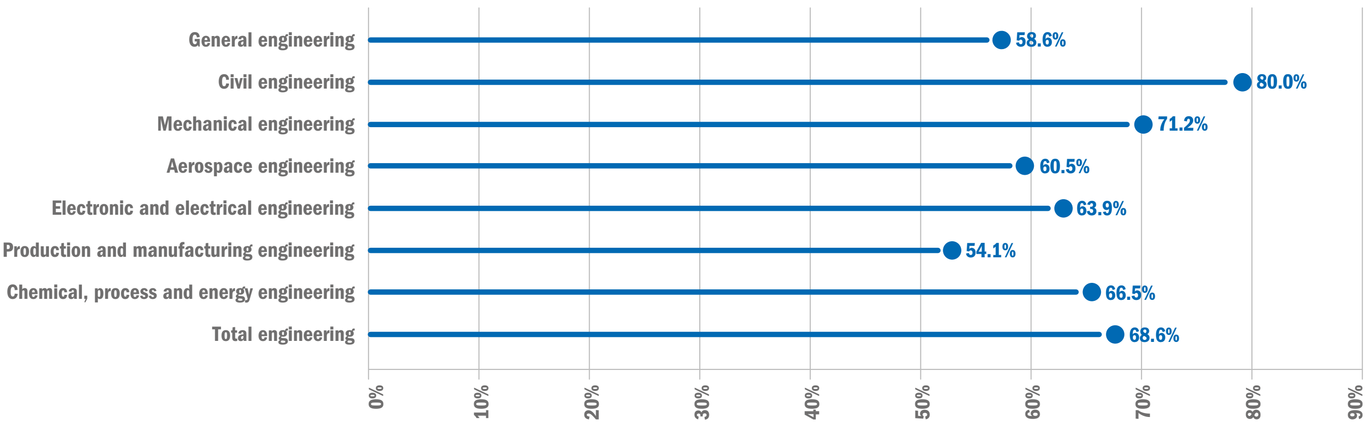
8.4.1 Employment in the engineering sector

Figure 8.4 shows the proportion of employed engineering graduates working for an organisation identified as within the engineering sector footprint, based on a range of detailed SIC codes.[8.13] The analysis is for UK-domiciled first degree graduates who had studied their programme full-time, ie the group entering the labour market as new graduate entrants. For all engineering disciplines combined, just under 69% were working for an engineering organisation. Figure 8.4 shows that the proportion was highest for civil engineering graduates, 80% of whom were working for an organisation in the engineering sector, and slightly higher than average for mechanical engineering graduates (72%). The proportions for general engineering (59%) and production and manufacturing (54%) were lower. The latter could well reflect the potential employability of graduates from this particular sub-discipline across a wide variety of industrial sectors.

8.4.2 Engineering sector employment: variations with gender and ethnicity

The headline figure of 69% of employed UK first degree engineering graduates working in the engineering sector six months after graduation varies only slightly by gender. Figure 8.5 shows that just under 66% of females in employment were working in the engineering sector. However, more pronounced variations emerge when we look at the data by ethnic background (Figure 8.6). While 72% of employed white engineering graduates went into the engineering sector, only 55% of Asian and 50% of black graduates did.

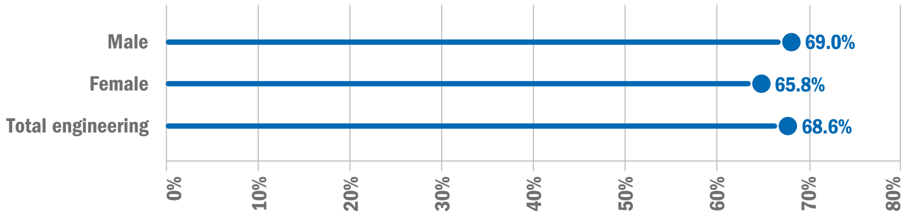
Figure 8.4: Proportion of employed first degree engineering graduates working for an engineering organisation, by sub-discipline (2014/15) – UK domiciles, full-time study



Source: HESA bespoke data request

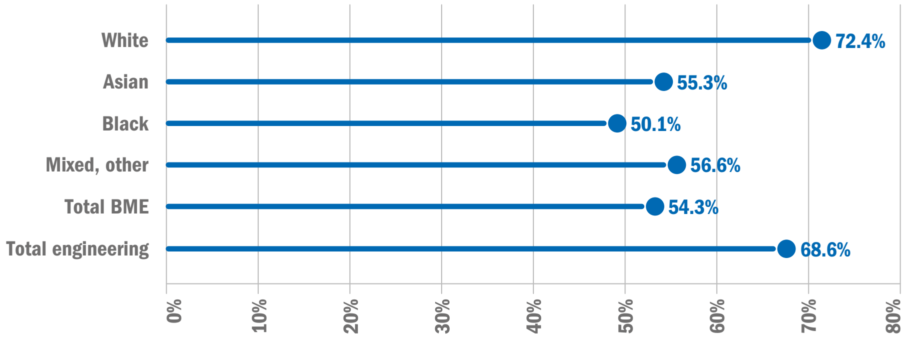
8.12 Only those graduates whose industry type could be identified at the 4 digit SIC code level were included in this analysis 8.13 The details of the SIC codes used in the EngineeringUK Engineering Footprint are available in the Annex to this publication

Figure 8.5: Proportion of employed first degree engineering graduates working for an engineering company, six months after graduation, by gender (2014/15) – UK domiciles, full-time study



Source: HESA bespoke data request

Figure 8.6: Proportion of employed first degree engineering graduates working for an engineering company, six months after graduation, by ethnicity (2014/15) – UK domiciles, full-time study



Source: HESA bespoke data request

8.4.3 Engineering graduates' employment in different industrial sectors

In the previous tables, we used a designated SIC footprint to analyse the number of employed engineering graduates who were working in the engineering sector six months after graduation. Table 8.10 uses more standardised industrial sectors. On this basis, it suggests that half of all employed engineering graduates were working in manufacturing (26%) or professional, scientific and technical activities (just under 24%) six months after graduation. Almost 10% were working in construction, and 6% in the ICT sector. Only the ten most popular sectors are shown.

The presence of sectors such as wholesale and retail, and accommodation and food service activities, may reflect engineering graduates working in these sectors long term. Equally, it could be due to recent graduates taking up temporary jobs in these sectors prior to starting a long term career.

Unsurprisingly, there was some variation in the industrial sectors that graduates from different engineering sub-disciplines entered. For example, significantly higher proportions (around 40% each) of employed mechanical, aerospace, and production and manufacturing

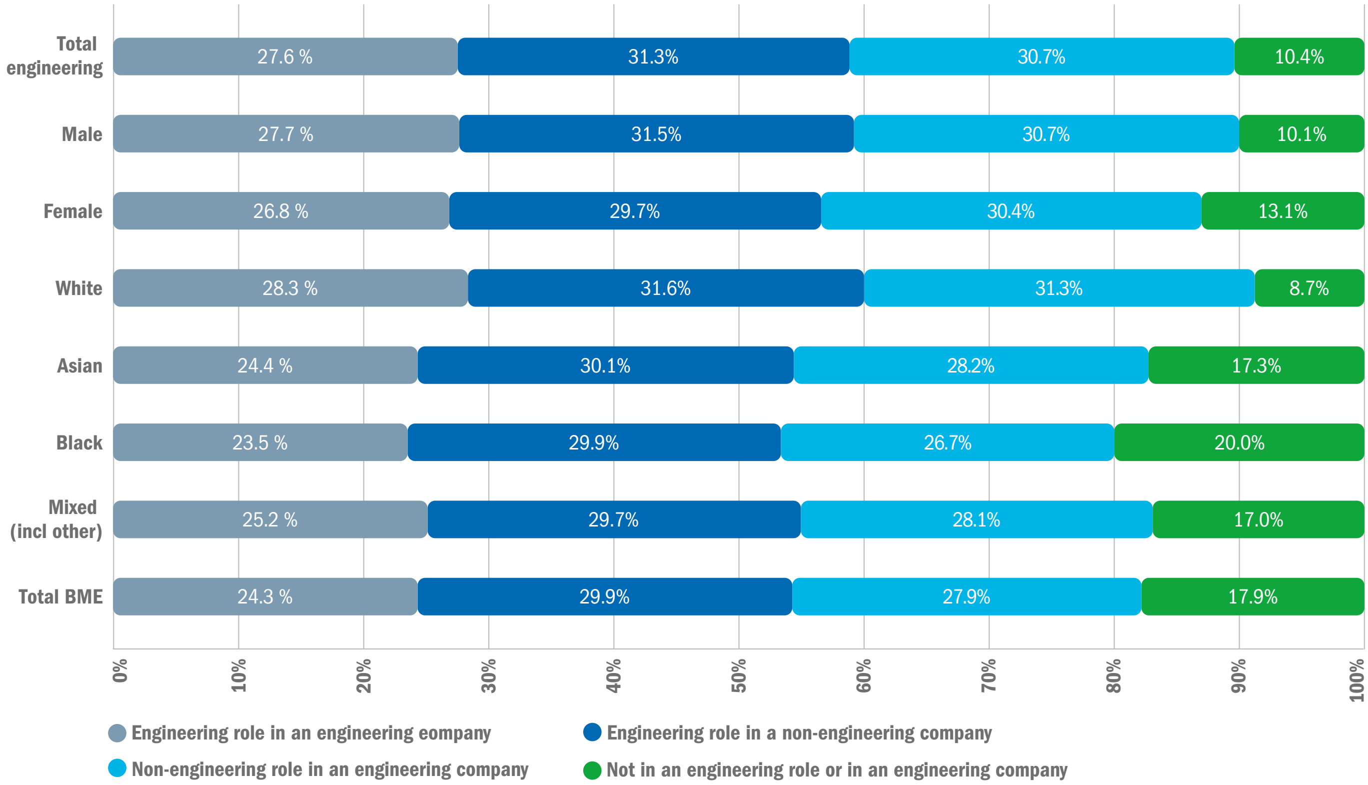
Table 8.10: Proportion of employed first degree graduates working in different industrial sectors, by sub-discipline (2014/15) – UK domiciles, full-time study[8.14]

	General engineering	Civil engineering	Mechanical engineering	Aerospace engineering	Electronic and electrical engineering	Production and manufacturing engineering	Chemical, process and energy engineering	Total engineering
Manufacturing	23.3%	2.7%	37.9%	37.0%	23.6%	40.1%	31.6%	26.3%
Professional, scientific and technical activities	27.3%	40.7%	19.9%	13.5%	17.1%	13.8%	19.7%	23.5%
Construction	4.7%	35.5%	3.5%	1.9%	3.0%	3.0%	4.2%	9.9%
Wholesale and retail trade; repair of motor vehicles and motorcycles	6.1%	3.6%	7.5%	8.5%	8.2%	11.0%	7.4%	6.9%
Information and communication	9.6%	0.9%	3.3%	4.7%	18.7%	5.7%	2.3%	6.3%
Accommodation and food service activities	3.6%	2.7%	3.8%	4.3%	3.7%	6.5%	3.8%	3.6%
Education	3.7%	1.2%	2.8%	3.7%	4.4%	6.2%	3.0%	3.1%
Mining and quarrying	1.2%	0.7%	4.4%	0.7%	1.4%	0.0%	11.3%	2.9%
Public administration and defence; compulsory social security	2.2%	2.6%	2.9%	7.5%	2.8%	0.8%	0.4%	2.9%
Financial and insurance activities	3.7%	1.6%	2.3%	3.7%	2.7%	1.7%	4.7%	2.7%
Number	**695**	**1,675**	**2,615**	**705**	**1,505**	**300**	**685**	**8,220**

Source: HESA bespoke data request

8.14 Only the ten most popular sectors, based on total engineering graduate proportions, are shown.

Figure 8.7: Proportion of full-time employed engineering graduates who worked for an engineering company and/or in an engineering role, by gender and ethnicity (2014/15) – UK domiciles, first degree, full-time study



Source: HESA destinations of leavers survey 2013/14

engineering graduates were working in manufacturing, while over 76% of civil engineers were working in either construction or professional, scientific or technical activities.

Focusing further on UK first degree engineering graduates in full-time employment, Figure 8.7 illustrates the proportions who were employed:

- in an engineering role within an engineering company (ie in both SIC and SOC footprints);
- in an engineering role in another sector;
- in an engineering company but not in an engineering role;
- in neither an engineering role or an engineering sector company.

The first of these groups, comprising just under 28% of all engineering graduates, was considered the 'core' of the engineering workforce in Chapter 3. At the other end of the spectrum, 10% were employed in neither an engineering occupation nor company.

These proportions varied only slightly with gender, with 28% of males but under 27% of females falling into the 'core' group, while 13% of females were in neither an engineering role nor company, compared with 10% of males.

The variance with ethnic background was somewhat stronger, with over 28% of white graduates in an engineering role and company but 24% of BME origin, and under 24% of black origin. Again, engineering graduates in neither an engineering role or company were under 9% of white, 18% BME and 20% black graduates.

These results suggest that white males are slightly more likely to secure jobs in the core engineering workforce, and BME graduates are slightly less likely.

Although not focused specifically on the engineering sector, the CBI has recently published a report focusing on the business case for improving the diversity of workplaces,[8.15] including some indicators of good practice in relation to recruitment.[8.16] In Section 8.7 of this chapter, we also include a case study from an employer on how an adjustment to its attraction and selection strategy led to significant improvements in the diversity profile of its recruits.

The Social Mobility Foundation and Social Mobility Commission have announced that they will publish an annual employer index of employers who can demonstrate the progress they have made in improving social mobility by ensuring they recruit and develop people regardless of social background.[8.17] Starting in spring 2017, this will be a benchmarking initiative targeted at sectors which, traditionally, have low rates of social mobility – including law, accountancy, banking and finance, and the sciences. Employers will volunteer to take part and be ranked on the following activities:

- Working with young people – recognising programmes that reach out to a wide spectrum of the country's talent, with appropriate routes into the employer/profession;
- Routes into work – well-structured non-graduate routes that provide parity of esteem and comparable progression to graduate routes;
- Attraction – innovative ways of reaching out to non-graduates and to graduates across the full range of universities;
- Recruitment and selection – evidence that the employer removes any hurdles that disproportionately affect those from lower socio-economic groups, and is moving to selection based on potential rather than purely prior academic performance or polish;
- Data collection – rigorous analysis of the profile of the workforce and measures taken to improve its diversity;
- Progression – effective strategies to help those from lower socio-economic groups progress once they have been recruited.

8.15 CBI: *Time for Action: the business case for inclusive workplaces*, 2016. http://www.cbi.org.uk/news/time-for-action-the-business-case-for-inclusive-workplaces/ 8.16 CBI: *Chapter 3 Attracting the right people gives businesses a long-term competitive advantage. In, Time for Action: the business case for inclusive workplaces*, 2016. http://www.cbi.org.uk/time-for-action-/3._Attracting_the_right_people.html
8.17 Social Mobility Commission: *Social mobility employer index*, October 2016. http://www.socialmobility.org.uk/social-mobility-employer-index/

8.5 Insights into engineering graduate employment

By Dr Rhys Morgan, Director, Engineering and Education, Royal Academy of Engineering

The Royal Academy of Engineering has recently published a report on analysis undertaken by the Careers Research & Advisory Centre (CRAC) on the employment destinations of recent engineering graduates from UK HE institutions.[8.18] The study presents a detailed analysis of the factors affecting engineering graduate employment and provides new insights into longer-term graduate employment outcomes for engineering.

The analysis used Higher Education Statistics Agency (HESA) Destinations of Leavers of Higher Education (DLHE) data for first destinations between 2009/10 and 2013/14 to examine trends. In addition, data from the 'Longitudinal DLHE' survey, which records outcomes 40 months after graduation, were also available for the cohort that graduated in 2010/11. This enabled CRAC to provide some tracking of this cohort from six months to 3.5 years after graduation.

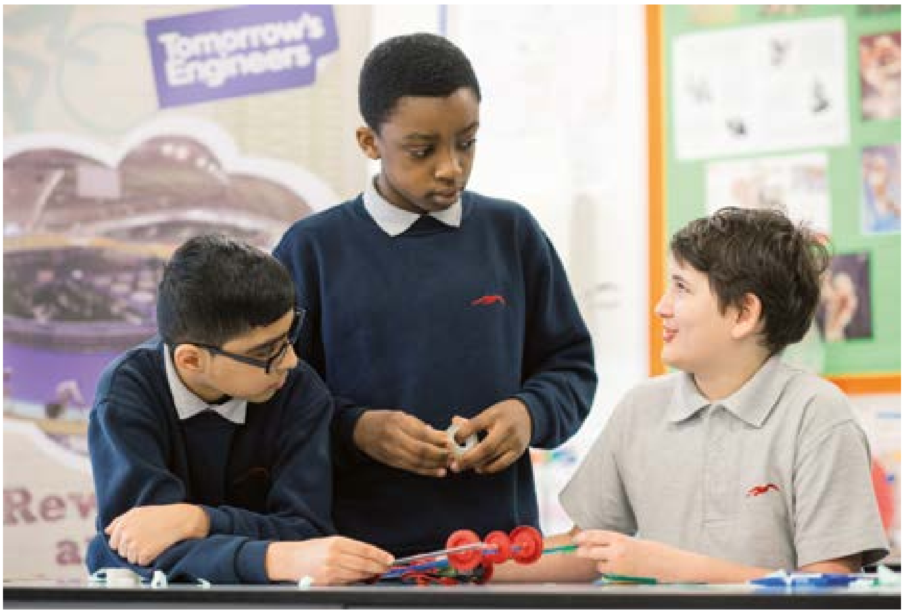
The general results of the study show the importance of engineering skills to the economy, with overall employment outcomes from engineering being very strong. For UK-domiciled, first degree engineering graduates from 2010/11 who had studied full-time:

- 81% had entered full-time work, were pursuing further study or a combination of both six months after graduation;
- This rose to 94% three and a half years after graduation;
- These proportions were both about 8 percentage points higher for engineering graduates than for all graduates combined.

The outcomes for engineering graduates in 2013/14 were similar, with 81% in full-time work, further study or a combination of both six months after graduation. This compares to 76% for graduates across all subjects.

The analysis also shows that employment outcomes within engineering occupations specifically were very strong:

- 55% of all 2013/14 engineering graduates had entered engineering occupations after six months, while just under 20% pursued further study;
- This proportion was 47% for 2010/11 engineering graduates, but rose to 70% after three and a half years.



This shows that most engineering graduates wanted to continue in engineering careers following their studies. This is a positive endorsement of the quality of engineering higher education and encouraging news for the UK engineering industry.

The study also analysed employment outcomes of engineering graduates by different diversity characteristics, such as gender, age and ethnicity. In addition, the research examined other factors such as degree classification, prior attainment (on the basis of UCAS tariff points) and HE institution attended (in three broad groups: Russell Group, other 'pre-92' and 'post-92' institutions).

8.5.1 Key findings on first destinations

Gender

A key issue for the engineering community is the very poor gender diversity across the sector, with only around 12-15% of women in the undergraduate engineering cohort, and a lower proportion still in the professional engineering workforce. However, the data showed:

- There were only small differences between male and female engineering graduates in terms of their outcomes after six months – slightly more men entered full-time employment than women, but more women than men pursued further study, the reverse of the trends observed for all graduates;
- There was a small difference in the proportion of male and female engineering graduates entering engineering occupations for the 2013/14 cohort, 56% of men and 52% of women took on engineering roles.

Ethnicity

While the employment outcomes of women relative to men in engineering are encouraging, the stark differences in outcomes for white and minority ethnic graduates is concerning.

- There was a 20 percentage point difference between the proportion of white engineering graduates entering full-time employment (71%) and their black and minority ethnic (BME) counterparts (51%) after six months;
- Black engineering graduates had the lowest proportion in full-time work at 46%;
- After six months, 60% of white engineering graduates were employed in engineering occupations, compared with only 40% for BME graduates and 37% for black graduates;
- Six months after graduation, 14% of black engineering graduates were unemployed, compared with only 7% of white engineering graduates;
- These differences were significantly greater for engineering graduates than across all subjects.

Degree classification

- For the 2013/14 cohort, UK engineering graduates with a 2:1 or above were significantly more likely to be in full-time employment six months after graduation (69%) than graduates with a 2:2 or below (53%);
- There was a 20 percentage point difference between the proportion of engineering graduates with a 2:1 or higher who were working in an engineering occupation (60%), compared with graduates with a 2:2 or below (40%).

8.18 Royal Academy of Engineering: *Employment outcomes of engineering graduates: Key factors and diversity characteristics*, November 2016. http://www.raeng.org.uk/eng-grad-destinations

Regression analysis

Many of the factors impacting on employment outcomes are inter-related. Therefore, a statistical regression analysis was undertaken to understand the relative weighting of the various influences. The results of the analysis show that, controlling for all other factors, ethnicity is a major characteristic affecting employment outcomes, particularly for engineering roles.

The reasons for this are not fully understood. There is evidence to suggest that students from BME backgrounds may not always have as much social capital to draw on as their white counterparts. Also, current student recruitment is often targeted at universities with lower proportions of BME students. More work needs to be undertaken to properly understand the factors that are causing weaker employment outcomes among BME graduates, and why these differences are greater for engineering graduates.

This analysis also demonstrated that obtaining a 2:2 or below and studying at a post-92 university were key factors associated with unemployment, especially for engineering graduates.

8.5.2 Longer term graduate destinations

The longer term (40-month) L-DLHE survey data showed very positive results for 2010/11 graduates who had studied an engineering degree:

- There was a positive longer term full-time employment outcome for engineering graduates, rising from 60% after six months to 84% after 40 months, and compared favourably with the proportion of all graduates in full-time employment by that stage (73%);
- 54% of engineering graduates were in engineering occupations after six months but this had risen to 69% after 40 months;
- Only 2% of engineering graduates were unemployed 40 months after graduation, similar to the rate for all graduates.

8.5.3 Conclusions

Between 2009/10 and 2013/14, increasing proportions of engineering graduates entered full-time employment within six months of graduation and decreasing proportions of graduates were finding themselves unemployed at that stage. These trends were seen for all graduates and are in line with the recovery of the graduate labour market following the UK recession.

Across the period, the data consistently demonstrates that a high proportion of engineering graduates enters full-time employment within six months of graduation compared with all graduates. Encouragingly for the engineering community, a significant majority (70%) of engineering graduates enter engineering occupations, dispelling previous concerns that most graduates are being lost to other sectors.

The study also confirms findings from previous research that ethnicity has a larger impact on the early employment outcomes for engineering graduates than the average graduate. Some differences with ethnicity persist 40 months after graduation but, by this point, the employment outcomes for BME graduates in engineering are similar to those for BME graduates across all subjects. The initial weak employment outcomes for BME graduates in engineering is of concern and more work needs to be undertaken to better understand why this is happening.

The recruitment of engineering graduates appears to correlate more highly with measures of academic attainment (class of degree, UCAS tariff) than the recruitment of all graduates. This is particularly evident in recruitment into engineering occupations. It suggests there is greater emphasis on academic attainment in engineering employer recruitment, rather than other measures of graduates' potential, compared with graduate recruitment in general. Conclusions cannot be made about the impact of integrated master's (MEng) compared to BEng degree courses from this research, however, so employers may have a preference for MEng graduates and this could be fuelling the differences.

8.6 Graduate recruitment and starting salaries

8.6.1 The UK graduate recruitment market

There are signs that the UK referendum result and acceptance of 'Brexit' are having some impact on the graduate recruitment market in the UK.

At the close of 2015, intelligence suggested that the market for graduates was healthy after four years of growth. Based on information from 100 of the UK's best-known employers, there was an expectation of significant growth during 2016 (potentially around 7% more vacancies), on the back of three consecutive years of increases. With over 3% more graduates hired by these organisations in 2015, this would take recruitment beyond the pre-recession peak in 2007 – possibly to its highest ever level.[8.19] Over one thousand graduate positions remained unfilled by these employers in 2015. The biggest growth in vacancies was expected to be in the public sector, banking and finance, and engineering and industrial companies.

However, recent survey data from the Association of Graduate Recruiters (AGR) suggest that graduate vacancy numbers may not have grown in 2016 after all. The 2016 AGR Survey was run during July and August 2016, shortly after the UK referendum result, and its results suggest that many employers have reacted to this and, in some cases, shifted more of their focus to apprenticeship programmes.[8.20] Based on data from 154 employers (and a total of around 23,000 vacancies), the total number of graduate vacancies fell by 8% compared with comparable data for 2015 (Table 8.11). This contrasted with a similar AGR survey from early 2016 that showed expected growth in vacancy numbers of 2% over the rest of that year.

The 2016 AGR Survey data shows that the biggest decline in graduate vacancies was in the retail sector (16%), with significant falls in engineering-related industry (14%) and construction (12%). The ICT sector was the only large sector to report continued growth (5% during 2016). It will be important to monitor these trends to see the extent to which they are genuine shifts, with employers focusing more on the school-leaver or apprenticeship market, or purely short-term reactions to the referendum result which are not borne out in longer-term graduate recruitment.

8.19 High Fliers Research: *The graduate market in 2016*, 2016. http://www.highfliers.co.uk/download/2016/graduate_market/GMReport16.pdf **8.20** AGR: *AGR 2016 Survey*, September 2016. https://www.agr.org.uk/AGR-Annual-Survey-2016

Table 8.11: Graduate and internship vacancies in 2016 (compared with 2015) from employers responding to 2016 AGR Survey

	% of 22,960 graduates	% change in volume year-on-year	% of 9,390 interns	% change in volume year-on-year
Overall	100%	-8% ↓	100%	+13% ↑
Accountancy or professional services firm	22.7%	-8% ↓	17.4%	+19% ↑
Public sector	14.8%	-7% ↓	7.2%	+51% ↑
Retail	10.6%	-16% ↓	7.9%	+1% ↑
Banking or financial services	10.4%	-8% ↓	22.2%	+13% ↑
Engineering or industrial company	10.2%	-14% ↓	10.2%	-3% ↓
IT and telecommunications	8.2%	+5% ↑	0.9%	-
Law firm	5.4%	-5% ↓	17.0%	-
Construction company or consultancy	5.4%	-12% ↓	5.8%	+25% ↑
FMCG company	2.4%	+1% ↑	2.4%	+14% ↑
Investment bank or fund managers	1.5%	+24% ↑	1.9%	-
Energy, water or utility company	1.4%	+2% ↑	2.0%	-24% ↓

Source: Association of Graduate Recruiters

One trend that does seem established is the role of internships in the recruitment process. Almost three-quarters of the AGR's employers reported hiring interns in 2016, with a 13% year-on-year increase in the number of internships on offer. The employers reported that 45% of 2015 interns went on to secure graduate jobs in the same companies, with one in ten employers converting four out of five of their interns into graduate hires.[8.21]

However, the growth in internship vacancies was not evenly distributed across industrial sectors, as can also be seen in Table 8.11, which is based on data from 112 employers and 9,390 internship vacancies. There was strong relative growth in the number of internship vacancies in the public sector (from a low base), in accountancy and professional services, banking and financial services, fast-moving consumer goods, and construction. However, firms in the engineering and energy sectors are reporting that numbers of internship vacancies are falling not rising. There was no comparable data for employers in the ICT sector. It will be interesting to note whether this trend amongst engineering employers is representative of all engineering employers at graduate level, as this could suggest its recruiters are not responding to the graduate market in the same way as other key industrial sectors.

There was also evidence that employers are targeting their efforts towards earlier stages of higher education, and even before, in an attempt to maintain security of their supply chain of graduate-level talent. The majority offer paid work experience programmes for students and recent graduates. Three-quarters are reported to provide paid vacation internships for penultimate year students and over half offer industrial placements for undergraduates.[8.22] An increasing number now also have work experience places for first year undergraduates, as well as introductory courses, open days and other taster experiences. Crucially, almost half of these recruiters warn that graduates with no previous work experience at all are unlikely to be successful during the selection process and will have little or no chance of receiving an offer for a graduate employment programme.

What is less clear is the extent to which these trends extend to smaller employers and, specifically, smaller engineering employers. A further view of the recruitment marketplace is provided in Section 9.6.

8.6.2 Graduate starting salaries[8.23]

Table 8.12 shows the mean salaries reported by UK-domiciled graduates six months after graduation. (For simplicity, this has been called their starting salary.) This analysis has been restricted to UK-domiciled graduates who were employed full-time, and who studied for their degrees full-time. This grouping most closely represents those newly entering the labour market and therefore reflects starting salaries; many of those who studied part-time will have continued their employment while studying and returned to their role on graduation, so they are unlikely to have been paid a 'starting' salary.

In the 2016 edition of this publication, we compared the starting salaries of UK- and EU-domiciled graduates. This showed that EU graduates earned more highly on average than UK graduates. However, this could well have been a function of the location of their employment, rather than a true reflection of higher salaries. Therefore, we restricted our analysis to UK-domiciled students this year.

On this basis, the mean salary earned by all UK graduates entering the labour market in full-time jobs was just over £22,000 in 2014/15. At £25,880, engineering and technology graduates enjoyed the highest mean starting salaries of any subject other than medicine and dentistry and veterinary science, both of which have a longer degree duration. The engineering and technology graduates starting salary exceeded the all-subject mean of £22,000, and was quite close to the average annual salary in the UK across all ages and all occupations.

Computer science and mathematics graduates also earned relatively strongly, some way above the average for all graduates. From the other STEM subjects, biological sciences graduates and agriculture and related subjects graduates earned below (and physical sciences graduates were fractionally below) the all-subject average.

Table 8.12: Estimated salary of first-degree graduates in full-time employment, six months after graduation, by broad subject group (2014/15) – UK domiciles, full-time study

Subject area	Mean salary £
Medicine and dentistry	28,967
Subjects allied to medicine	22,636
Biological sciences	19,054
Veterinary science	27,347
Agriculture and related subjects	19,867
Physical sciences	21,679
Mathematical sciences	24,915
Computer science	24,114
Engineering and technology	25,880
Architecture, building and planning	22,641
Social studies	22,722
Law	19,679
Business and administrative studies	21,933
Mass communications and documentation	18,618
Languages	19,904
Historical and philosophical studies	24,037
Creative arts and design	18,466
Education	20,989
Combined	21,702
Total	22,022

Source: HESA bespoke data request

8.21 AGR: *Graduate Recruitment: AGR annual survey highlights increased value of internships* (web page), September 2016. https://www.agr.org.uk/Graduate-Recruitment-News/agr-annual-survey-highlights-increased-value-of-internships#.V_uH-IWcGEY **8.22** High Fliers Research: *ibid* **8.23** Not all respondents to the DLHE survey provide salary information; data were provided in salary brackets: up to £5,000, then in bands rising by £1,000 up to £69,000, and then all salaries £70,000 or over.

Figure 8.8 compares the mean starting salary for engineering graduates in full-time employment with that of comparable graduates of all subjects combined (UK domiciled, full-time study). It shows that there is a starting salary premium for engineering graduates at both taught postgraduate and first degree level of study. The chart also shows that postgraduate degree holders command a significantly higher starting salary than first degree graduates, although the premium enjoyed by engineering graduates over others is only marginal at doctoral level. A further interesting observation is that the starting salary for a first degree engineering graduate is very similar to that of an average graduate with a taught postgraduate degree.

Comparable results for graduates of foundation degrees and other undergraduate programmes have been excluded, as many study part-time. In many cases, these types of programme are studied by mature students who will have already spent a period in employment, so their salaries on return to the labour market (or their old job) might not be reflective of those 'starting' in the labour market.

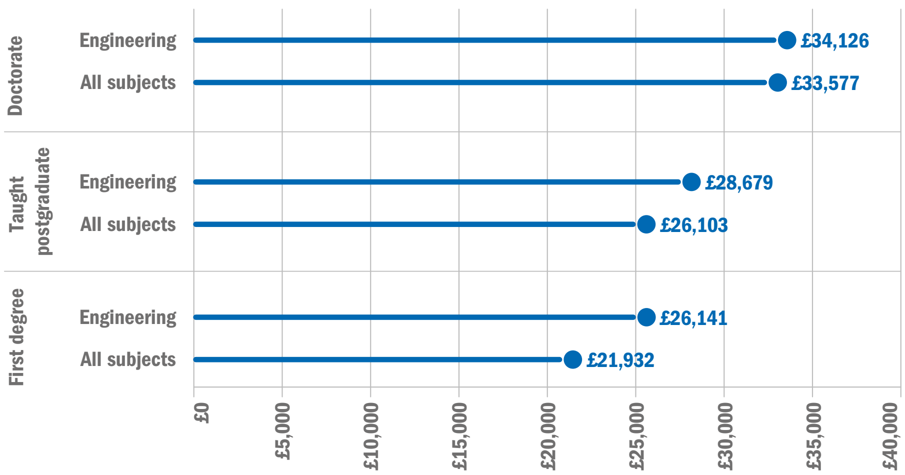
Use of this more tightly defined sample prevents us from directly comparing the most recent starting salary data with that reported in the 2016 edition of this publication. However, we can make comparisons with data from the AGR Survey. This is genuine starting salary data, although it is based on employer sector not degree subject, and comes from only a sample of all employers. AGR also reports median starting salaries, rather than mean. However, the mean starting salary reported by AGR for engineering graduate vacancies in 2016 was £26,500,[8.24] which is very close to the mean salary for engineering and technology graduated stated in Table 8.12. AGR has recorded similar data for many consecutive years; the starting salary in engineering the previous year was £25,750, indicating a rise of around 3% in 2016. This was higher than the 2% rise experienced across all sectors combined.[8.25]

Starting salaries for vacancies in the ICT sector were higher in 2016 at £29,000, having risen just under 2% from the previous year, while in construction they were similar to the engineering sector.

Another issue worthy of analysis is the occupation that the graduate enters. Table 8.13 shows the mean starting salary for UK engineering graduates in full-time employment. The mean value for those working in engineering occupations was £26,723, which was nearly 12% higher than comparable graduates in another occupation.

Table 8.13 also looks at the employer's business sector and shows a slightly greater premium for working in an engineering company: at £26,796, the mean salary was 13% higher in engineering companies than in non-engineering companies. It should be noted that these salary figures are lower than those quoted in the 2016 edition of this publication, as the results given this year are restricted to UK-domiciled, first degree graduates.

Figure 8.8: Estimated mean salary for UK graduates in full-time employment six months after graduation, by level of degree (2014/15) – UK domiciles, full time study



Source: HESA bespoke data request

Table 8.13: Estimated mean salary earned by engineering graduates in full-time employment six months after graduation, by whether they worked in an engineering occupation or for an engineering company or not (2014/15) – UK domiciles first degree, full-time study

	Mean salary £
Engineering role	26,723
Non-engineering role	23,893
Engineering company	26,796
Non-engineering company	23,816

Source: HESA bespoke data request

8.6.3 Engineering graduate starting salary variations

Table 8.14 considers how starting salaries vary both with engineering sub-discipline and gender, based on 2014/15 UK engineering graduates who were employed full- time and had studied a first degree full-time.

All the mean sub-discipline starting salaries were within 9% of the all-engineering subject mean. Chemical, process and energy engineering graduates were the highest paid, at over £28,000. Production and manufacturing engineering graduates were the lowest paid, at £23,600. The three largest sub-disciplines – civil, mechanical, and electrical and electronic engineering – were within 1-2% of the overall mean.

For all engineering disciplines combined, there was a difference of less than £100 between mean starting salaries for male and female graduates. This reflects the observation made in Chapter 9 that there tends to be little or no gender pay gap for under 30s and that the gap is smallest of all in professional and technical occupations.

However, examining the gender pay gap by sub-discipline shows some more substantive differences. In mechanical engineering, female graduates' starting salaries were around 2% higher than males'. On the other hand, in electrical and electronic, production and manufacturing, and chemical, process and energy engineering, male graduates' starting salaries were around 5% higher.

It must be pointed out that this analysis takes no account of the occupations that the graduates enter, so there is no immediate suggestion here

8.24 AGR: *AGR 2016 Survey*, September 2016. https://www.agr.org.uk/AGR-Annual-Survey-2016 8.25 AGR: *AGR 2015 Annual Survey*, July 2015. https://www.agr.org.uk/AGR-Surveys of a pay gap for comparable jobs. In fact, given that engineering occupations tend to be relatively well paid, the gender differences in electrical and electronic engineering and production and manufacturing engineering could be explained by the lower numbers of women entering engineering occupations (Table 8.6). However, the lower starting salary for female graduates in chemical, process and energy engineering is more concerning, as this is the sub-discipline with the highest proportion of female students, and the highest proportion entering an engineering occupation.

Table 8.14: Estimated mean salary for engineering graduates in full-time employment six months after graduation, by selected sub-discipline and gender (2014/15) – UK domiciles first degree, full-time study

		Mean salary £
General engineering	Male	26,755
	Female	26,736
	Total	26,751
Civil engineering	Male	25,885
	Female	25,663
	Total	25,849
Mechanical engineering	Male	26,273
	Female	27,014
	Total	26,331
Aerospace engineering	Male	25,765
	Female	25,739
	Total	25,762
Electronic and electrical engineering	Male	25,683
	Female	24,087
	Total	25,528
Production and manufacturing engineering	Male	23,888
	Female	22,595
	Total	23,556
Chemical, process and energy engineering	Male	28,283
	Female	27,310
	Total	28,030
Total engineering	Male	26,040
	Female	25,947
	Total	26,027

Source: HESA bespoke data request

Analysis presented in last year's edition of this publication suggested that white engineering and technology graduates enjoyed a significantly higher average starting salary than graduates from ethnic minority backgrounds (based on 2013/14 DLHE data). However, this may have been affected by the inclusion of EU graduate data for a variety of degree levels as well as UK graduate data. This year, we have constrained the analysis to UK-domiciled first degree graduates who studied full-time (from the 2014/15 DLHE survey). This enables a more robust comparison and results in a much smaller variance (Table 8.15).

Across all subjects combined, the mean starting salaries of graduates from ethnic minority backgrounds were slightly higher than for white graduates, with a variance of around 5% between the highest earning (Asian graduates) and lowest (white). This variance is much lower than between graduates of different subjects, and suggests that, encouragingly, ethnic background may not be a major factor in graduate starting salaries.

For engineering, however, there was some evidence for small-scale variances. White engineering graduates had a mean starting salary of £26,220: 2% higher than all BME graduates and 5% higher than black graduates. On the other hand, the figure for Asian graduates was almost indistinguishable from that for white graduates. Similar analysis recorded in earlier DLHE cohorts suggests that much more significant differences existed five years ago between white and ethnic minority origin engineering graduates,[8.26] so the situation has improved.

It would be interesting to pursue this analysis further, to understand in which sectors or occupations these variances persist for engineering graduates.

Table 8.15: Estimated mean salary six months after graduation for first degree engineering graduates in full-time employment, by ethnicity (2014/15) – UK domiciles, first degree, full-time study.

		Mean salary £
Engineering		
	Asian	26,091
	Black	24,924
	Mixed, other	25,481
	White	26,220
	Total BME	25,713
	Total engineering	26,027
All subjects		
	Asian	22,816
	Black	22,298
	Mixed, other	22,507
	White	21,770
	Total BME	22,605
	Total	22,022

Source: HESA bespoke data request

Recently, administrative educational data and data held on individuals by Her Majesty's Revenue & Customs (HMRC) have been linked. This is a significant development in research into graduate earnings, as it will enable analysis over a longer term and factoring in student characteristics (including educational and personal background) and study characteristics (course, university attended etc.). One of the first research studies using this data has shown that graduates from richer family backgrounds earn significantly more after graduation than their poorer counterparts, even after completing the same degrees from the same universities.[8.27] The study also showed that graduates are much more likely to be in work, and earn much more, than non-graduates.

8.26 Engineering Professors Council: *Improving the employment chances of engineering graduates, Presentation to 2014 EPC Congress*, April 2014: http://epc.ac.uk/wp-content/uploads/2014/04/Session-1-Robin-Mellors-Bourne-Employment-diversity-research-summary.pdf 8.27 IFS: *How English-domiciled graduate earnings vary with gender, institution attended, subject and socio-economic background*, April 2016. http://www.ifs.org.uk/publications/8234

A further finding was that there can be quite substantial differences in earnings related to the subject studied (as we have suggested in Table 8.12) and the university attended. Table 8.16 provides further evidence of the significance of choice of university: 2014/15 UK engineering graduates from Russell Group universities enjoyed a mean starting salary of over £27,000 for full-time employment, compared with just under £25,500 for graduates from other UK universities.

Russell Group membership is based on universities' research intensiveness. However, it is also taken as an indicator of prestige, and these universities tend to have high entry tariffs for undergraduates. These universities offer many of the integrated master's (MEng) courses, which are more rarely offered by post-1992 universities. It seems likely that many employers will target MEng graduates, and this could well have an impact on the starting salaries achieved by engineering graduates in different types of university.

Previous analysis has shown similar effects for those who obtain higher degree classes (ie a 1st or 2:1 class of first degree) compared with lower attainment (2:2 or 3rd class). This effect is greater for engineering graduates than graduates across all subjects.[8.28]

These results suggest that starting salaries for graduates are dependent on a wide range of factors, including characteristics of study (subject, type of university, degree class and type) as well as, to a lesser extent, personal characteristics (gender, ethnicity). What this analysis, of course, cannot identify is the role of other factors that are known to be important in graduate recruitment, such as the salary attached to a specific job, or the extent of work experience.

Table 8.16: Estimated mean salary six months after graduation for first degree engineering graduates in full-time employment, by broad type of university attended (2014/15) – UK domiciles first degree, full-time study

University type	Mean salary £
Russell group member	27,197
Other	25,458

Source: HESA bespoke data request

8.7 Increasing diversity in recruiting engineering graduates – a case study

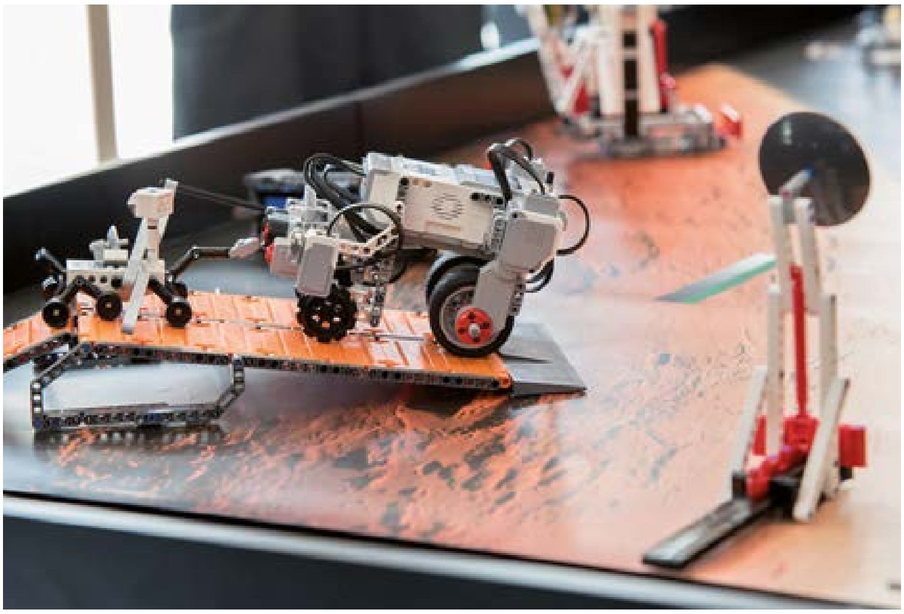
By Alasdair Waddell, Group Talent Acquisition Manager, Network Rail

The positive impact of a diverse workforce on the overall performance of an organisation is well documented. It has been demonstrated that diversity of thought can improve communication, increase innovation and raise levels of motivation. At Network Rail, we have acknowledged at the very top of the organisation that we need to increase the diversity of a workforce that is 16% female and has only 6% from an ethnic minority background. Given the increase in demand for engineers across the UK and internationally, it will also benefit our recruiters to widen the talent pool that we are fishing in.

As part of a wider culture change programme, Network Rail has focused on increasing the diversity of the future leaders of the rail industry: namely, our graduates. To this end, a research project named 'Not for people like me' was jointly commissioned with WISE[8.29] and conducted by Professor Averil MacDonald at the University of Reading. This research provided targeted recommendations to remove unconscious bias in advertising, recruitment and selection processes and recommendations to enhance the appeal of Network Rail careers by invoking a sense of 'belonging' in potential applicants. As part of an ongoing commitment to supporting the talent pipeline from school, Network Rail became founding sponsor of the revolutionary *People Like Me* WISE STEM careers resource pack.

In addition, the Network Rail 'emerging talent' resourcing team commissioned and conducted research specific to the graduate market to understand perceptions of Network Rail as a graduate employer. We found that knowledge of the role of the company and the wider industry was limited and expectations of careers in rail were low, as this focus group quote revealed: "There is a sentiment that the organisation is about maintenance, not development or innovation. It feels limited and contained."

Given the ambition of the task, budget constraints and the need for a consistent message over the long term, we knew we could not achieve everything in one annual campaign. The objective in Year 1 was to widen the appeal of the Network Rail graduate scheme by challenging misconceptions and dispelling myths about the careers we offer and the people we employ. The messaging and imagery were overhauled to emphasise the range of careers available and the impact of our work on the wider economy and society. The headline was



8.28 Engineering Professors Council: *ibid* 8.29 Women in Science and Engineering: *Welcome to People Like Me* (web page). https://www.wisecampaign.org.uk/about-us/wise-projects/people-like-me

‘Network Unlimited’ to convey the fact that we offer a wide range of disciplines and career paths, along with positive support from the company, so you can personally shape your career. We compete with City banks, financial and professional services firms for the attentions of talented undergraduate engineers, so we focused on the value of the work we do and the benefits to society as a whole.

Year 2 further developed the look and feel of the campaign to include our current graduates and reflect our inclusive and supportive culture. We invested in photography, videos and people profiles to showcase our current graduate engineers. Traditional advertising was supplemented by local and national press articles focusing on the personal stories and careers of some of our more experienced and successful engineers. All our people stories focused Network Rail’s culture of including and supporting colleagues. They also highlighted what our people get up to outside their day job, for example volunteering. This advertising campaign was backed by increased interaction on the ground. On campus, we built relationships with the engineering departments that allowed us to run bespoke sessions in lectures with a focus on soft skills like communication and interview techniques.

Over the two years, we increased the proportion of females across all our graduate schemes from 24% to 29% and the proportion of graduates from an ethnic minority background from 17% to 31%. For engineering specifically, we have reached a high point of 15% females and 45% BME graduates. When compared with the UK engineering undergraduate market as a whole, we know this is good (as around 15% of engineering and technology undergraduates are female and about 20% of all STEM students are from a British ethnic minority background). This is especially good when you consider that not all of these students go on to join engineering graduate schemes. However, we are also aware that our advertising can only take us so far, and that our selection process must also be open and inclusive.

Our initial attempts at reducing adverse impact for protected characteristics included ‘blind shortlisting’, unconscious bias training for assessors, and the combination of scores from multiple exercises to remove personal bias. These interventions worked, but as we have become more targeted in our messaging to specific demographics, we have had to take a more tailored approach to assessment to address cultural bias affecting specific groups. For example, we have replaced traditional psychometric tests by a ‘gamified’ ability test to reduce anxiety and cultural bias. The number of participants in the group exercise has been reduced from eight to four, to encourage participation from candidates of all ethnic origins. All of our selection tools have been adapted to be better predictors of success at Network Rail rather than focusing on past experience. Time will now tell how successful these changes will be, but we have learnt that to have a truly inclusive recruitment process, we must be aware of peoples’ differences rather than blind to them.

Part 3 - Engineering in Employment
9 Earnings in engineering and other STEM careers

Key points

Earnings trends

Despite the growth in the number of first-degree graduates in many countries, there still seems to be a 'graduate premium': on average, those with a degree earn more over a lifetime than those with lower level qualifications or none. The extent of this premium, however, may be falling.

In the economy overall, average earnings for full-time employees increased by 1.8% in 2015, continuing a trend for ten years of relatively weak growth of earnings. There are some signs lately that even this growth could be tailing off.

UK figures show a gender pay gap persists across the engineering sector, although it fell marginally (to 9.4%) last year. The gender pay gap varies greatly at different stages of a career, and by occupation – it is much lower in professional occupations including many engineering roles.

The job market is volatile at present, with fluctuations by sector and region that reflect skills shortages. These contribute to a complicated picture of earnings on the ground.

Average salaries

The mean salary for all those in full-time employment (all occupations/sectors) was £33,689, 0.5% higher than the previous year. The more representative median salary was up 1.6% to £27,645.

Looking more closely, mean earnings for some mainstream engineering professions look strong and some saw bigger rises. Civil engineering salaries, for instance, rose by 5% to £42,500 and mechanical engineering salaries rose by 3.6% to over £45,000.

Electrical engineering also averaged around £45,000, although this was a decrease from the previous year. These salary levels are similar to, or higher than, the average for chartered and certified accountants.

Mean part-time pay across all occupations fell compared with the previous year, but part-time work in some STEM occupations is well-remunerated. Part-time roles tend to be dominantly occupied by women.

At technician and skilled crafts levels, median salaries for many engineering-related roles are good and rising. Although they do not match earnings in the financial/business services sectors, many are considerably better than for some of the skilled roles in sectors such as the food and drink or textiles industries.

Regional and occupational variations

There remain strong regional variations for engineering occupations, with those in London earning the most. Overall, mean engineering salaries in many other regions and UK nations are much lower, but growing in all these regions/nations.

These regional variations can be outweighed by occupational variances – in 2015, mean earnings for several engineering roles were higher outside London. These variations reflect the local complexity of the labour market.

9.1 Context

9.1.1 The graduate premium puzzle

According to some, there is a synergistic relationship between productivity and earnings.[9.1] HM Treasury has claimed that if the UK's productivity matched the USA's, every household in the country would be £21,000 better off per year. The government has also admitted that every OECD country which has higher productivity than Britain also has higher average wages.[9.2]

Graduate earnings can be used as a proxy for productivity, as employers tend to be willing to pay more to employ more productive workers. In 2013, the National Institute for Social and Economic Research estimated that approximately one-third of the increase in UK labour productivity between 1994 and 2005 was the result of an increase of graduate skills in the labour force.[9.3] A substantial 'graduate premium' was calculated, based on simulation of the predicted earnings (and employment status) of individuals. This was thought to be around £168,000 in terms of average lifetime earnings net of tax and loan repayments for men, and £252,000 for women. The social benefit to the government was estimated to be of the same order of magnitude.[9.4]

The supply of graduates has increased vastly in recent years, and that growth has been much quicker in the UK than in most comparable countries. From simple laws of economics, this should result in a reduction to their relative wage advantage. However, there is mixed evidence as to whether this has actually happened. It seems that globalisation and technological change in the economy have increased the demand for the types of skills that graduates offer.[9.5] On this basis, several governments have acted to boost the supply of graduates to keep up with demand, in the expectation that this will power economic growth.

9.1 Cabinet Office: *Civil service quarterly – the productivity plan: a route map to a more prosperous nation* (blog), September 2015. https://quarterly.blog.gov.uk/2015/09/10/the-productivity-plan-a-route-map-to-a-more-prosperous-nation/ 9.2 Cabinet Office: *Civil service quarterly – the productivity plan: a route map to a more prosperous nation* (blog), September 2015. https://quarterly.blog.gov.uk/2015/09/10/the-productivity-plan-a-route-map-to-a-more-prosperous-nation/ 9.3 BIS: *The relationship between graduates and economic growth across countries*, August, 2013. https://www.gov.uk/government/publications/graduates-and-economic-growth-across-countries 9.4 BIS: *The impact of university degrees on the lifecycle of earnings: some further analysis*, August 2013. https://www.gov.uk/government/publications/university-degrees-impact-on-lifecycle-of-earnings 9.5 Institute for Fiscal Studies: *The puzzle of graduate wages*, August 2016. https://www.ifs.org.uk/uploads/publications/bns/bn185.pdf

The Institute for Fiscal Studies has considered this puzzle and concluded that a more highly educated workforce allows companies to reorganise.[9.6] They have tended to do this in ways that provide more autonomy for their graduate employees, which increases both companies' productivity and their demand for graduates. This is a positive change. Although there are early signs that the graduate premium might be starting to drop off, at least in the private sector, this is relative. In fact, all wages have been falling in real terms since the mid-2000s, but graduate wages have been decreasing less rapidly than non-graduate wages.

However, there is growing evidence that since 1995, the economic effect of having a degree has fallen substantially. While in 1995 a graduate earned an average 45% more than someone with no qualifications, this premium was thought to have fallen to 34% by 2015.[9.7] Increasingly, the existence and extent of the graduate premium is coming into question.

Nonetheless, the role of higher skills in avoiding the problem of low pay is well established. In 2014, for example, there were ten times more people earning below the UK minimum wage working in elementary occupations, than earning at that level in the professional occupations most likely to require a university degree.[9.8]

9.1.2 The gender pay gap

Inequality in remuneration between men and women is high on both the UK and the European policy agenda. Prime Minister Theresa May highlighted it in her first speech on her vow to create a fairer Britain, saying that, "If you're a woman, you will earn less than a man."[9.9] Former Prime Minister David Cameron had also vowed to "end the gender pay gap in a generation," and new legislation expected in April 2017 will force larger employers to publish their pay gap.

Eurostat, the EU's equivalent of the UK's Office for National Statistics, analyses data showing the extent of the gender pay gap across Europe.[9.10] While EU statistics are not directly comparable with those available in the UK, the average gender pay gap within the EU is 16%. Pay levels, however, vary hugely across Europe: in some areas women earn more on average than men, while in others, men earn 25% more on average than women. Eurostat also produces trends over time, suggesting that the pay gap across Europe has changed little in the past five years. Eurostat believes that the gender pay gap in the UK could be as high as 19.7% in 2013, on an unadjusted basis.

In the UK, the gender pay gap is calculated using data from the Annual Survey of Hours and Earnings (ASHE), which is carried out by the Office for National Statistics (ONS). Its headline estimates of the gender pay gap are for hourly earnings excluding overtime, and it uses median earnings. Caution is needed, however, because although median or mean hourly pay provide useful comparisons of men's and women's earnings, they do not reveal differences in rates of pay for comparable jobs, and this is the focus of equal pay legislation. In the absence of any national framework for job evaluation (as exists, for example, in some Eastern European countries), a national survey-based approach cannot take account of the demands in a job, so the headline figures for a gender pay gap cannot be treated as a robust indicator of whether women are receiving equal pay for equal work.

In the year to April 2015, average earnings for full time employees increased by 1.8%.[9.11] The gender pay gap for median earnings of full-time employees decreased to 9.4%, from 9.6% in 2014. This was the lowest gap since analysis began ten years ago, although the gap has changed relatively little over the last four years. For full-time employees, the gap is relatively small up to and including those aged 30-39 and, in the 22-29 age group, women are paid on average slightly more than men. From 40 upwards, the gap is much wider, with men being paid substantially more on average than women. In the private sector, the gender pay gap for full-time employees was 17.2% in 2015, while in the public sector it decreased slightly to 11.4%. For part-time workers, most of whom are female, there was actually a 'negative' pay gap, with women paid more than men.

In terms of occupational groups, the pay gap has consistently been high for those in the skilled trades (including electricians, for example), and also for managers and directors. On the other hand, it has consistently been lower than the national average for professional and associate professional occupations, within which many engineering graduates are employed.[9.12]

Other analysis suggests that women earn 18% less than men on average, which is closer to the figure quoted by Eurostat. Research by the Institute for Fiscal Studies (IFS)[9.13] echoes the ONS data in reporting that the gap rises after women have children, raising the possibility that mothers miss out on pay rises and promotions. However, this situation is improving: the gap in hourly wages was 23% in 2003 and 28% in 1993, according to IFS figures. Responding to campaign group the Fawcett Society, the IFS suggested that these findings underline the need for more part-time jobs of higher quality.[9.14]

9.1.3 Current volatility in the recruitment market

Our overview of the engineering recruitment market (Section 9.6) shows that demand appears to remain strong across much of the sector, with some significant variations relating to investment initiatives or other substantial industrial policy issues.

However, this trend needs to be viewed in the context of month-by-month volatility in the wider recruitment market. The ONS data for the three months to July 2016 suggest an annual rise in UK vacancies of only 0.3%, which was the weakest growth in over four years.[9.15] However, it is worth summarising a current monthly view, to demonstrate the impact of volatility on recruitment.

In the aftermath of the UK referendum in June 2016, staff appointments fell sharply across the industry, followed by a return to growth in August. At the time of writing (October 2016), data from recruitment consultant surveys[9.16] suggest that there were rises in both permanent and temporary/contract staff appointments during September, and the national vacancy indicator was also at its highest point since the referendum. This was largely fuelled by demand for staff by the private sector.
In the public sector, permanent vacancies continued to fall but temporary vacancies rose, presumably compensating for longer-term cost-cutting measures.

The recruitment consultant survey data suggest that engineering was the sector with highest relative demand for staff in September 2016, followed by health and social care and ICT. Construction, which is being strongly impacted by short-term fluctuations, was at the bottom end of this league table. Nonetheless, even in construction, there was a marginal increase in the number of vacancies in September.

The impact of this overall growth pattern was that permanent staff salaries continued to rise in September at much the same rate as the previous month. These latest salary increases are thought to be attributable to increasing demand, candidate and skills shortages and a high volume of available senior roles. The rate of salary growth was highest in Scotland.

9.6 IFS: *ibid* **9.7** Bank of England: *Wages, productivity and the changing composition of the UK workforce*, Quarterly Bulletin 2016 Q1, March 2016. http://www.bankofengland.co.uk/publications/Documents/quarterlybulletin/2016/q1pre.pdf **9.8** EngineeringUK: *The state of engineering 2016*, January 2016. http://www.engineeringuk.com/Research/ **9.9** Prime Minister's Office: *Statement from the new Prime Minister Theresa May* (speech), July 2016. https://www.gov.uk/government/speeches/statement-from-the-new-prime-minister-theresa-may **9.10** Eurostat: *European Regional Yearbook 2016*. http://ec.europa.eu/eurostat/statistical-atlas/gis/viewer/ **9.11** ONS: *Annual survey of hours and earnings: 2015 provisional results (statistical bulletin)*. http://www.ons.gov.uk/employmentandlabourmarket/peopleinwork/earningsandworkinghours/bulletins/annualsurveyofhoursandearnings/2016provisionalresults **9.12** DCMS: *Secondary analysis of the gender pay gap: changes in the gender pay gap over time*, March 2014. https://www.gov.uk/government/publications/secondary-analysis-of-the-gender-pay-gap **9.13** IFS: *The gender wage gap*, August 2016. https://www.ifs.org.uk/publications/8435 **9.14** The Fawcett Society: *Fawcett responds to IFS report on gender pay gap widening for mothers* (web page), August 2016. http://www.fawcettsociety.org.uk **9.15** ONS: *UK labour market: September 2016*. https://www.ons.gov.uk/employmentandlabourmarket/peopleinwork/employmentandemployeetypes/bulletins/uklabourmarket/september2016 **9.16** IHS Markit and the Recruitment & Employment Confederation: *Report on jobs* (press release), October 2016. https://www.markiteconomics.com/Survey/PressRelease.mvc/712df67c73a748dcb6091d2468d5b60a

Hourly rates of pay for staff in short-term employment rose again in September – albeit at the slowest rate in 3 years.

Demand and pay for temporary work was highest in the South East of England. ONS data indicated a slight weakening in overall earnings growth in the three months to July, with an average weekly earnings growth amounting to 2.1% annually.[9.17] This was the slowest increase since the start of the year.

Meanwhile, consumer price inflation was 0.6% in August, meaning that the gap between the rates of earnings growth and inflation was at its lowest for 18 months, and is expected to narrow further. With an expected continuation of depreciation in the value of the pound, it is thought that consumer price inflation will be higher in 2017. If earnings growth continues to slow, consumer spending is likely to reduce, which could in turn slow the UK's economic growth.

In this chapter the focus is on annual earnings in selected STEM-related occupations at professional, technical, and also associate technician levels, as well as for a number of craft careers or skilled trades. It includes variations with gender where the data is comparable.

9.2 Annual gross pay for selected STEM professions

9.2.1 Full-time employment

Table 9.1 considers the mean and median values for those in full-time employment in selected STEM professional and technical occupations in 2015. The mean salary for all those in full-time employment (all occupations/sectors) was £33,689 – 0.5% higher than the previous year. The median figure, which is possibly more representative, was £27,645, which was 1.6% above the 2014 median. Both these figures demonstrate the relatively weak growth of earnings overall during 2014-2015.

Within the individual professional occupations, there was considerable volatility, with many salaries falling and some rising. Civil engineers on average earned over £42,500, which was an increase of over 5% on the previous year. Mechanical engineers earned over £45,000 – up 3.6%. Electrical engineers' earnings also averaged £45,000, although this was a decline of 4.6%. Salaries for all these mainstream disciplines were similar to, or higher than, the average salaries for chartered and certified accountants. Certain professions earned much more still, including airline pilots, medical doctors and IT directors (although the latter experienced a significant decline in mean pay in 2015).

Table 9.1: Annual mean and median gross pay for full-time employees in selected STEM professions by gender (2015) – UK[9.18, 9.19]

Occupation	All full-time					Male					Female				
	Number of jobs	Mean	Annual percentage change	Median	Annual percentage change	Number of jobs	Mean	Annual percentage change	Median	Annual percentage change	Number of jobs	Mean	Annual percentage change	Median	Annual percentage change
Aircraft pilots and flight engineers	9,000	£87,474	-7.1	£84,867	-6.1	9,000	£88,069	-6.5	£85,476	-5.5	-	-	-	-	-
Medical practitioners	132,000	£80,628	1.5	£76,275	6.0	80,000	£90,580	0.7	£88,866	3.6	53,000	£65,650	3.2	£58,795	6.4
Information technology and telecommunications directors	27,000	£70,971	-17.0	£65,717	1.9	23,000	£72,063	-19.8	£65,881	2.1	-	£65,114	1.5	-	-
Research and development managers	36,000	£52,923	-3.9	£44,656	-0.9	26,000	£56,680	-6.1	£45,459	-	10,000	£42,779	1.3	£40,169	3.9
Health services and public health managers and directors	34,000	£51,603	-1.2	£45,439	0.9	16,000	£53,678	0.2	£49,468	4.7	18,000	£49,824	-2.9	£41,687	-1.0
IT specialist managers	131,000	£49,464	-1.6	£45,450	1.3	110,000	£50,419	-2.9	£46,063	0	21,000	£44,426	6.7	£38,280	6.4
Electrical engineers	19,000	£45,571	-4.6	£43,611	-0.2	18,000	£45,293	-5.5	£42,656	-2.9	-	£50,696	14.3	£45,589	8.1
Production managers and directors in manufacturing	418,000	£54,671	-0.8	£44,786	0.3	341,000	£56,751	-0.2	£46,257	1.6	77,000	£45,391	-2.2	£37,267	-4.3
Mechanical engineers	32,000	£45,429	3.6	£42,564	4.4	30,000	£45,722	2.5	£42,610	3.7	-	£41,033	-	£37,608	-
IT business analysts, architects and systems designers	84,000	£47,155	1.2	£43,340	3.6	74,000	£47,917	3.3	£43,981	4.6	10,000	£41,521	-13.5	£37,839	0.2
Production managers and directors in construction	77,000	£51,125	-2.6	£42,366	5.9	71,000	£51,080	-2.8	£43,143	7.9	-	-	-	-	-
Engineering professionals n.e.c.	124,000	£42,396	0	£40,349	3.5	107,000	£43,133	-0.4	£41,033	3.9	-	£37,798	5.2	£35,780	5.3

9.17 ONS: *Earning and working hours* (web page). https://www.ons.gov.uk/employmentandlabourmarket/peopleinwork/earningsandworkinghours 9.18 Employees on adult rates who have been in the same job for more than a year. 9.19 Figures for number of jobs are for indicative purposes only and should not be considered an accurate estimate of employee job counts.

Programmers and software development professionals	160,000	£41,794	-0.3	£39,644	-1.2	74,000	£47,917	3.3	£43,981	4.6	-	£39,533	2.7	£36,654	1.8
Design and development engineers	64,000	£41,132	-1.1	£38,453	-0.6	60,000	£41,487	-1.7	£38,477	-0.9	-	£35,177	0.8	£33,250	3.3
Waste disposal and environmental services managers	8,000	£42,359	3.9	£34,004	-2.8	-	£43,419	0	£35,158	-5.2	-	£38,577	21.3	-	-
Information technology and telecommunications professionals n.e.c.	70,000	£41,696	-2.5	£38,016	-4.1	59,000	£42,868	-1.6	£40,670	0.5	12,000	£35,675	-3.6	£33,197	-5.0
Quality assurance and regulatory professionals	61,000	£47,746	3.2	£39,818	3.7	38,000	£51,411	4.2	£41,201	6.1	23,000	£41,752	2.6	£38,274	5.9
Production and process engineers	37,000	£39,770	3.0	£38,341	3.9	33,000	£40,313	1.9	£38,546	2.5	-	£35,154	11.7	£33,129	3.9
Civil engineers	39,000	£42,788	5.1	£40,165	4.2	36,000	£43,397	4.9	£41,014	4.3	-	£35,518	7.8	£33,844	11.0
Managers and directors in transport and distribution	60,000	£43,473	1.3	£37,625	1.6	52,000	£44,154	2.8	£38,602	3.2	8,000	£38,751	-	£31,617	-
Pharmacists	24,000	£44,249	4.8	£41,703	0.5	9,000	£47,807	2.2	£45,390	-1.1	-	£37,700	4.9	£37,739	3.6
Construction project managers and related professionals	16,000	£40,492	-0.6	£34,150	1.5	14,000	£42,034	-0.4	£35,689	2.6	-	£29,527	15.9	£27,613	24.5
Architects	25,000	£44,883	-3.0	£38,355	1.1	-	£48,154	-2.4	-	-	6,000	£35,058	4.5	£33,000	2.2
Chartered and certified accountants	63,000	£42,887	1.4	£38,476	2.0	35,000	£47,424	0.4	£41,734	-0.7	28,000	£37,138	3.2	£34,939	6.4
Natural and social science professionals n.e.c.	36,000	£39,528	1.4	£36,525	1.5	23,000	£38,877	-2.8	£36,752	0.3	13,000	£40,671	8.7	£36,438	9.0
Biological scientists and biochemists	41,000	£41,415	-0.8	£38,051	-0.1	21,000	£45,048	-0.1	£40,753	0.6	20,000	£37,581	-1.3	£34,152	-4.3
Quality control and planning engineers	33,000	£37,637	0.8	£36,030	0.6	28,000	£37,856	1.4	£35,984	1.1	-	£36,309	-3	£35,923	-5.4
Business, research and administrative professionals n.e.c.	46,000	£39,716	4.0	£36,087	4.6	28,000	£41,039	2.9	£36,870	4.1	18,000	£37,638	6.3	£34,771	5.5
Chartered surveyors	49,000	£38,897	1.6	£34,983	0.1	42,000	£39,749	1.2	£35,199	-2.0	7,000	£33,671	6.4	£29,925	0.3
Chemical scientists	11,000	£37,559	4.8	£33,157	1.0	8,000	£41,113	8.5	£36,676	10.1	-	£28,939	-2.3	£27,326	-
Ophthalmic opticians	-	£40,152	-3.2	£36,315	-5.7	-	£42,173	-13.5	-	-	-	£37,778	4.1	£36,329	-1.9
Environment professionals	-	£33,338	7.3	£30,866	9.9	21,000	£34,705	2.2	£32,225	1.5	7,000	£31,354	1	£28,368	-0.2
Medical radiographers	24,000	£36,479	2.6	£34,458	0.9	9,000	£39,321	3.5	£35,683	1.3	16,000	£34,931	1.9	£34,247	2.7
Conservation professionals	8,000	£32,823	7.5	£33,412	9.5	-	£33,993	6.8	£34,991	6.1	-	£29,941	9.5	£29,217	-
Web design and development professionals	28,000	£31,291	1.7	£29,876	2.9	22,000	£31,815	1.7	£29,930	0	-	£29,116	2.8	£28,544	1.8
Managers and proprietors in other services n.e.c.	61,000	£37,787	-0.2	£29,999	0.5	39,000	£40,446	0.1	£31,876	-0.4	22,000	£33,064	-1.6	£26,633	-1.2
All full-time workforce	15,703,000	£33,689	0.5	£27,645	1.6	9,530,000	£37,123	0.1	£29,934	1.6	6,173,000	£28,388	1.4	£24,202	1.4

Source: ONS – Annual Survey of Hours and Earnings

Back to Contents

Although Table 9.1 appears to be evidence of a gender pay gap, this should not be taken at face value. The figures are averages from a range of salaries for different individual jobs, grouped under these occupational headings. A difference by gender for an occupation is not strictly therefore a pay gap, as the latter should be limited to comparable jobs. The large difference in mean salary for men and women aggregated across the entire employment range (£37,000 against £28,000) underlines this lack of comparability. It does, however, illustrate that more women are in lower paid jobs. Looking at some of the engineering occupations, female electrical engineers were on average paid more than their male equivalents, but the reverse was the case for mechanical and civil engineers. The data should therefore be treated with caution, although it does provide an interesting snapshot at the individual occupational level.

Table 9.1 also gives a view of the relative numbers employed in these occupations, expressed in thousands. Together, they make up 2.3 million of the total 15.7 million in the workforce who are employed full-time. Production managers and directors in manufacturing are the largest group, showing the extensive contribution to STEM employment made by the manufacturing sector. The figures also give profiles by gender: in many cases, the figure for size of the female segment of an occupation is not large enough for publication and has been suppressed, although salary data is given where available.

9.2.2 Part-time employment

As expected, average part time annual pay, across all occupations, was lower than full-timepay (£11,503 compared with £33,689), and had risen very little in 2015 compared the previous year's figure (Table 9.2). The table shows size and pay data for part time employees in a selection of STEM occupations at professional level, although the number employed on this basis within individual occupations is not always large enough for data to be available.

Over three quarters of the 5.9 million employees in the data were female, showing the dominance of women in part-time employment. The absence of data for many of the STEM professional occupations in the table, especially for men, is evidence that the numbers who work in many of these male-dominated roles part-time is small. On the other hand, many health-related professions are included, which feature much higher representation of women and higher availability of part-time roles. Nonetheless, Table 9.2 indicates that in a number of STEM occupations there are relatively well-remunerated part-time roles, with average salaries close to many full-time graduate starting salaries.

9.20 See notes to Table 9.1

Table 9.2: Annual mean and median gross pay for part-time employees in selected STEM professions by gender (2015) – UK[9.20]

Occupation	All part-time					Male					Female				
	Number of jobs	Mean	Annual percentage change	Median	Annual percentage change	Number of jobs	Mean	Annual percentage change	Median	Annual percentage change	Number of jobs	Mean	Annual percentage change	Median	Annual percentage change
Medical practitioners	32,000	£38,103	3.7	£30,879	13.0	13,000	£45,821	6.6	-	-	19,000	£32,672	-0.3	£30,180	9.2
Health services and public health managers and directors	-	£28,386	15.1	-	-	-	-	-	-	-	-	£27,366	17.5	-	-
Production managers and directors in manufacturing	61,000	£14,593	-3.3	£10,000	11.1	39,000	£12,843	-15.3	£9,924	18.3	22,000	£17,799	18.8	-	-
Programmers and software development professionals	8,000	£22,059	0.4	£19,213	-	-	£20,219	4.2	-	-	-	£24,211	-1.5	-	-
Pharmacists	12,000	£23,819	-1	£22,844	-4.7	-	£24,299	-	-		10,000	£23,707	-1.7	£22,525	-6.8
Chartered and certified accountants	12,000	£19,921	8.8	-		-	£13,109	-	-	-	7,000	£24,959	31.3	£21,489	22
Biological scientists and biochemists	-	-	-	-	-	-	£26,438	94.8	-	-	-	-	-	-	-
Business, research and administrative professionals n.e.c.	7,000	£22,035	-7.6	£21,642	-3.0	-	£19,506	-15.2	-	-	-	£23,290	-3.8	£22,417	0
Medical radiographers	10,000	£22,112	4.6	£21,788	5.8	-	£20,560	1.1	£19,115		8,000	£22,465	5.3	£22,420	0.8
Managers and proprietors in other services n.e.c.	8,000	£16,520	-7.5	£12,952	-6.8	-	-	-	-	-	6,000	£15,413	-20.4	£12,848	-7.6
Entire occupations/sectors	5,931,000	£11,503	0.3	£9,275	3.1	1,365,000	£12,086	-0.3	£8,956	3.6	4,566,000	£11,329	0.5	£9,368	3.0

Source: ONS – Annual Survey of Hours and Earnings

9.3 Annual gross pay for selected STEM technician and craft careers

9.3.1 Full-time employment

It has been suggested earlier in this publication that the engineering workforce consists of over 5.7 million people, which represents around 18-19% of the total UK workforce (of around 31 million people). Within the engineering and STEM workforces, over 2 million people are employed in what can be termed 'STEM technician' occupations. Of these, around 1.4 million are thought to be employed in skilled worker roles (eg IT and telecommunications engineers, electricians and electrical fitters) and around 0.75 million in associate professional occupations, such as laboratory technicians, engineering technicians and other technically-skilled roles such as those running or maintaining technical equipment.[9.21]

Table 9.3 illustrates the gross annual mean and median pay in 2015 for those working in these types of occupation full-time, who between them comprise just under 2 million of the total 15.7 million full-time employees for whom data is available. The data shows the large size of some of these occupations, particularly in the electrical sector and trades, and in production and manufacturing, including vehicle manufacture. The relatively small number of these occupations for which data for females can be shown is evidence of how male-dominated some of these occupations are, especially in the electrical sector, as the number of females in these jobs are too small to show.

Although the highest mean and median salary figures are for financial and accounting technicians (who are likely to be professionally qualified), using the more representative median salaries shows that many of the engineering-related technician roles pay around £30,000 annually. It is also noticeable that technician-level occupations in the engineering sector, such as those working on aircraft or in telecommunications, are considerably better paid than some of the skilled roles in the food and drink or textiles industry.

Comparison of male and female mean salaries reveals a very mixed picture. There was considerable volatility in salaries for many occupations compared with the previous year, although several skilled trade roles experienced substantial rises in mean and/or median earnings. For instance, there were good returns in IT and telecommunication engineering, presumably reflecting local skills shortages. Overall, however, the picture has been of weak earnings growth.

9.21 TBR: *Understanding the UK STEM technician workforce*, September 2014. http://www.gatsby.org.uk/uploads/education/reports/pdf/pn03513o-understanding-uk-stem-technicians-finalreport-v1-1.pdf

Table 9.3: Annual mean and median gross pay for full-time employees in selected STEM technican and craft career roles, by gender (2015) – UK[9.22]

	All full-time					Male					Female				
Occupation	Number of jobs	Mean	Annual percentage change	Median	Annual percentage change	Number of jobs	Mean	Annual percentage change	Median	Annual percentage change	Number of jobs	Mean	Annual percentage change	Median	Annual percentage change
Financial and accounting technicians	22,000	£49,266	-1.4	£39,736	-0.6	12,000	£53,030	-7.7	£44,508	-4.9	9,000	£44,293	9.3	£32,377	5.5
Aircraft maintenance and related trades	13,000	£34,397	-1.1	£33,523	-2.9	13,000	£34,881	-1.1	£33,564	-7.3	-	-	-	-	-
Skilled metal, electrical and electronic trades supervisors	43,000	£36,157	0.3	£32,757	-0.5	41,000	£36,331	0.3	£33,036	-1.8	-	£32,904	1.5	£28,299	-5.1
Engineering technicians	71,000	£36,066	2.4	£34,327	2.0	64,000	£36,389	2.5	£34,820	2.5	7,000	£33,144	0.6	£29,593	0.7
Telecommunications engineers	34,000	£33,746	4.0	£31,945	1.5	33,000	£33,971	4.1	£32,010	1.4	-	£25,243	-8.0	£26,518	-3.3
Electrical and electronics technicians	11,000	£30,171	1.2	£29,179	-3.4	10,000	£30,740	1.7	£29,712	-3.6	-	£18,684	-4.0	-	-
Electrical and electronic trades n.e.c.	110,000	£31,741	0.4	£29,503	-0.5	107,000	£31,678	-0.1	£29,413	-1.0	-	£33,998	-	£31,747	-
Electricians and electrical fitters	117,000	£31,453	0.7	£30,444	0.9	116,000	£31,476	0.5	£30,433	0.7	-	£29,353	11.7	-	-
Water and sewerage plant operatives	8,000	£31,329	2.4	£30,456	0.1	8,000	£31,968	4.4	£30,504	1.5	-	-	-	-	-
Metal plate workers, and riveters	-	£31,191	3.0	£29,637	-3.1	-	£31,191	3.0	£29,637	-3.1	-	-	-	-	-
Precision instrument makers and repairers	-	£29,542	-2.2	£28,569	-4.9	9,000	£29,799	-2.7	£29,490	-2.4	-	-	-	-	-
Assemblers (vehicles and metal goods)	49,000	£32,036	5.9	£32,333	10.6	45,000	£32,684	6.0	£33,033	11.5	-	£24,798	7.7	£22,298	8.7
Metal working production and maintenance fitters	292,000	£30,860	1.2	£29,241	1.5	285,000	£31,052	1.5	£29,408	1.9	8,000	£23,611	-10.3	-	-
Product, clothing and related designers	19,000	£30,649	1.6	£29,684	4.8	10,000	£31,997	0.4	£31,988	2.6	9,000	£29,143	2.6	£27,556	6.3
Draughtspersons	27,000	£30,969	2.4	£27,938	1.2	24,000	£31,259	1.4	£27,913	-0.6	-	£28,545	-	£27,188	-
Plumbers and heating and ventilating engineers	49,000	£28,756	-0.7	£29,136	2.0	48,000	£28,870	-0.5	£29,162	2.0	-	£23,480	-9.7	-	-
IT operations technicians	82,000	£32,310	2.4	£29,110	4.3	60,000	£33,211	1.7	£29,781	4.8	22,000	£29,858	4	£28,010	6.7
IT user support technicians	110,000	£30,495	0.3	£28,606	0.1	85,000	£31,572	0.8	£29,222	0.7	26,000	£26,913	-1.3	£25,323	-2.2
Planning, process and production technicians	29,000	£33,273	1.8	£30,355	2.3	21,000	£35,871	6.0	£32,543	4.8	8,000	£26,087	-3.3	£24,430	0.6
Architectural and town planning technicians	-	-	-	-	-	8,000	£30,578	1.0	£28,951	1.7	-	-	-	-	-
TV, video and audio engineers	7,000	£28,475	1.8	£27,132	-0.9	7,000	£28,562	2.1	£27,354	-0.1	-	-	-	-	-
Tool makers, tool fitters and markers-out	8,000	£27,527	0	£26,462	3.4	8,000	£27,785	0.5	£26,586	3.7	-	-	-	-	-
Energy plant operatives	5,000	£30,097	-0.7		-	5,000	£30,897	-0.3	-	-	-	-	-	-	-
Quality assurance technicians	23,000	£28,682	0.4	£27,001	-0.6	15,000	£29,470	-1.2	£27,736	-2.1	8,000	£27,228	5.2	£25,899	7.7
IT engineers	13,000	£29,336	7.9	£26,516	-	12,000	£28,891	7.6	£26,521	8.6	-	-	-	-	-

Medical and dental technicians	18,000	£29,876	0.8	£28,725	3.0	11,000	£31,852	0.2	£29,941	-0.2	7,000	£26,498	0.1	£22,887	-1.2
Vehicle paint technicians	8,000	£25,280	0.9	£23,691	-4.1	8,000	£25,321	1.1	£23,754	-3.6	-	-	-	-	-
Metal machining setters and setter-operators	59,000	£27,899	1.3	£26,095	1.8	57,000	£28,150	1.4	£26,467	1.4	-	£20,250	-0.4	-	-
Science, engineering and production technicians n.e.c.	103,000	£28,097	-0.1	£26,250	-1.0	91,000	£28,826	-0.5	£26,940	-0.4	13,000	£22,816	3.9	£21,682	4.9
Welding trades	43,000	£27,994	3.7	£25,421	3.0	42,000	£28,144	4.0	£25,492	3.2	-	-	-	-	-
Sheet metal workers	10,000	£26,905	-3.4	£23,491	-14.7	10,000	£27,096	-4.0	£23,623	-15	-	-	-	-	-
Metal making and treating process operatives	9,000	£26,772	4.5	£24,625	2.3	9,000	£26,772	4.8	£24,625	2.5	-	-	-	-	-
Vehicle technicians, mechanics and electricians	108,000	£25,745	0.4	£25,016	1.0	106,000	£25,860	0.6	£25,037	1.0	-	£18,242	-10.1	-	-
Process operatives n.e.c.	7,000	£26,551	7.2	£25,652	7.8	7,000	£27,246	4.2	£28,072	10.1	-	£16,104	7.4	£16,096	-
Vehicle body builders and repairers	22,000	£26,447	4.8	£25,031	1.3	22,000	£26,509	4.9	£25,044	0.9	-	-	-	-	-
Chemical and related process operatives	22,000	£28,842	4.9	£25,934	3.2	19,000	£30,577	5.3	£27,834	5.9	-	£20,083	6.4	£18,686	2.3
Routine inspectors and testers	43,000	£24,626	-1.0	£22,521	-1.5	30,000	£26,734	0.9	£25,307	0.9	13,000	£19,682	-3.2	£18,488	-1.3
Plant and machine operatives n.e.c.	13,000	£25,409	1.7	£23,002	0.4	12,000	£25,875	0.4	£24,065	-0.1	-	£21,603	13.6	-	-
Electroplaters	5,000	£23,994	5.5	£21,920	4.3	5,000	£24,340	5.4	£22,444	2.2	-	-	-	-	-
Metal working machine operatives	20,000	£22,696	2.7	£20,601	0.7	17,000	£23,408	2.1	£21,843	1.9	-	£19,297	10.5	£18,216	11.8
Elementary construction occupations	39,000	£22,032	-0.6	£21,048	0.5	38,000	£22,084	-0.6	£21,156	0.9	-	£16,409	-15.3	£15,104	-18
Pharmaceutical technicians	14,000	£23,534	1.3	£21,006	0.6	-	£29,073	8.1	£28,478	9.7	11,000	£22,379	0	£20,498	2.4
Printing machine assistants	16,000	£21,850	-1.7	£19,887	-2.9	12,000	£22,932	-1.4	£22,003	-6.5	-	£18,358	-1.6	£17,305	2.8
Assemblers (electrical and electronic products)	14,000	£21,992	5.5	£21,016	3.6	9,000	£23,332	3.5	£22,885	2.2	-	£19,239	7.7	£18,943	8.1
Paper and wood machine operatives	21,000	£21,246	-1.1	£19,500	-0.8	19,000	£21,704	-1.0	£20,122	-0.9	-	£16,788	-2.1	£15,992	-
Laboratory technicians	42,000	£24,420	-0.7	£21,792	-0.3	22,000	£27,260	0.3	£24,427	-2.3	19,000	£21,167	-1.3	£19,084	-1.2
Textile process operatives	-	£21,195	-4.4	£20,685	3.9	7,000	£23,198	-2.9	£22,464	2.3	-	£17,051	2.1	£17,083	-5
Elementary process plant occupations n.e.c.	80,000	£20,348	-1.0	£19,310	1.1	67,000	£21,091	-1.5	£19,893	-0.6	14,000	£16,721	3.1	£15,515	2.6
Glass and ceramics process operatives	5,000	£24,634	14.6	£21,895	16.0	-	£25,734	19.1	£23,560	22.7	-	£16,932	-	£16,477	-
Tyre, exhaust and windscreen fitters	12,000	£20,340	-5.7	£18,684	-8.8	12,000	£20,340	-5.7	£18,684	-8.8	-	-	-	-	-
Food, drink and tobacco process operatives	113,000	£19,278	-0.1	£17,923	0	75,000	£20,525	0	£19,131	0.6	38,000	£16,779	1.4	£15,849	1.3
Industrial cleaning process occupations	10,000	£18,378	-1.0	£17,629	-2.1	7,000	£18,909	-1.0	£18,293	2.1	-	£16,839	-1.0	£17,452	-1.6
All occupations/sectors	15,703,000	£33,689	0.5	£27,645	1.6	9,530,000	£37,123	0.1	£29,934	1.6	6,173,000	£28,388	1.4	£24,202	1.4

Source: ONS – Annual Survey of Hours and Earnings

9.22 See notes to Table 9.1

9.3.2 Part-time employment

Table 9.4 shows the mean and median pay for selected part-time STEM technicians and craft careers by gender. (Only a relatively small number of occupations are of sufficient size for full data to be supplied for part-time employees.) This analysis only covers around 100,000 part-time employees, which is a minority of the total part-time workforce. This indicates either that a large variety of other roles also have small numbers and/or that part-time employment in these technician roles is relatively uncommon.

Again, financial and accounting technicians come across as the most highly paid group in this analysis, followed by those working in the IT and medical sectors, although robust comparison would require more knowledge of the terms of employment. For most of these occupations, the scale is insufficient to learn much in terms of differences by gender, although women comprise most of those working part-time as laboratory and engineering technicians, and those in the food and drink production sector.

Table 9.4: Annual mean and median gross pay for part-time employees in selected STEM technician and craft career roles, by gender (2015) – UK

	All part-time					Male					Female				
	Number of jobs	Median	Annual percentage change	Mean	Annual percentage change	Number of jobs	Median	Annual percentage change	Mean	Annual percentage change	Number of jobs	Median	Annual percentage change	Mean	Annual percentage change
Financial and accounting technicians	-	£19,757	-11.9	£17,482	-8.2	-	£14,769	-6.1	-	-	-	£20,648	-10.4	-	-
IT operations technicians	8,000	£14,378	-8.9	-	-	-	£11,967	-10.5	-	-	-	£15,470	-8.4	-	-
IT user support technicians	-	£15,921	0.3	-	-	-	-		-	-	-	-	-	-	-
Medical and dental technicians	7,000	£17,597	7.8	-	-	-	£13,698	-12.4	£13,522	-	-	£18,801	14.0	-	-
Science, engineering and production technicians n.e.c.	9,000	£13,494	-4.3	£12,534	-	-	£13,000	-11.5	-	-	6,000	£13,680	-0.2	£12,289	-7.6
Elementary construction occupations	5,000	£10,199	-14.4	-	-	5,000	£10,199	-14.4	-	-	-	-	-	-	-
Laboratory technicians	11,000	£11,133	-5.8	£10,449	-3.3	-	-		-	-	9,000	£11,216	-8.2	£10,777	-0.8
Elementary process plant occupations n.e.c.	9,000	£10,498	1.6	£8,876	-4.9	6,000	£11,744	-3.3	£9,245	-	-	£8,573	4.0	-	-
Food, drink and tobacco process operatives	20,000	£10,814	-5.3	£9,856	-8.1	-	£12,722	-3.9	-	-	12,000	£9,669	-2.8	£9,101	-6.5
Industrial cleaning process occupations	4,000	£8,055	3.5	£6,076	-2.5	-	£9,458	18.9	-	-	-	£7,038	-8.5	-	-
All employees	5,931,000	£11,503	0.3	£9,275	3.1	1,365,000	£12,086	-0.3	£8,956	3.6	4,566,000	£11,329	0.5	£9,368	3

Source: ONS – Annual Survey of Hours and Earnings

9.4 Engineering salary variations across the UK

As noted elsewhere in this report, employment levels and earnings vary across the UK nations and regions. Table 9.5 presents a regional analysis of the mean salaries for those employed in some of the key engineering occupations. (To reduce the segments with too little data, both full-time and part-time earnings data is used for all employees.)

Across all occupations, those in London have much the highest annual mean earnings, at over £40,000, although earnings have fallen slightly since 2014. Mean salaries in many other regions and nations were much lower, but in all cases had grown since 2014.

However, mean earnings for several engineering occupations were higher outside London. For example, civil engineers earned more on average in Scotland (£48,600) and in the South East (£48,000), while mechanical engineer averages were highest in Scotland and Wales, but also high in London and the South East. Electrical engineers in London, the South East and Eastern England earned particularly highly,

Table 9.5: Annual mean salaries for full-time and part-time employees in selected engineering occupations, by region (2014-2015) – UK

	Year	North East	North West	Yorkshire and The Humber	East Midlands	West Midlands	East of England	London	South East	South West	Wales	Scotland	Northern Ireland	United Kingdom
Civil engineers	2015	-	£38,241	£39,412	£43,499	£38,091	£40,849	£40,013	£47,906	£32,051	£39,825	£48,600	-	£42,061
	2014	£32,837	£40,410	£34,749	£41,894	£40,364	-	£40,992	£42,541	£33,626	£33,300	£41,188	-	£40,200
Mechanical engineers	2015	£28,644	£47,104	£39,126	£41,008	£46,585	£39,915	£46,805	£48,785	£41,945	£61,758	£52,029	-	£44,837
	2014	£43,029	£44,222	£34,386	£43,029	£43,029	£43,029	£43,029	£43,029	£43,029	£43,029	£43,029	-	£43,029
Electrical engineers	2015	-	£39,461	£45,674	-	£41,335	£51,377	£54,586	£53,223	£35,924	£32,442	£40,062	-	£44,996
	2014	£46,984	£52,216	£40,651	£46,984	£46,984	£46,984	£46,984	£46,984	£46,984	£46,984	£46,984	-	£46,984
Electronics engineers	2015	-	-	-	-	-	£37,883	£35,978	£52,352	£39,090	-	-	-	£43,892
	2014	£41,685	-	£39,753	£41,685	£41,685	£41,685	£41,685	£41,685	£41,685	£41,685	£41,685	-	£41,685
Design and development engineers	2015	£43,562	£35,354	£40,823	£37,203	£36,762	£36,493	£61,164	£37,866	£41,461	£36,428	£42,118	-	£40,058
	2014	£40,245	£34,941	-	£40,245	£40,245	£40,245	£40,245	£40,245	£40,245	£40,245	£40,245	-	£40,245
Production and process engineers	2015	£34,687	£38,454	£36,913	£40,026	£36,727	£34,067	£45,018	£43,744	£37,097	£38,155	£41,930	-	£39,510
	2014	£38,223	£38,800	£34,604	£38,223	£38,223	£38,223	£38,223	£38,223	£38,223	£38,223	£38,223	-	£38,223
Engineering professionals n.e.c.	2015	£39,288	£40,914	£34,816	£39,139	£44,593	£41,630	-	£42,964	£38,356	£37,456	£49,568	-	£41,966
	2014	£41,453	£41,833	£31,949	£41,453	£41,453	£41,453	£41,453	£41,453	£41,453	£41,453	£41,453	-	£41,453
Quality control and planning engineers	2015	£38,478	£34,414	£30,699	£35,977	£33,325	£38,310	£42,209	£37,354	£33,361	£35,221	£39,525	-	£37,005
	2014	£36,454	£35,601	£35,181	£36,454	£36,454	£36,454	£36,454	£36,454	£36,454	£36,454	£36,454	-	£36,454
Engineering technicians	2015	£32,878	£33,668	£35,257	£34,393	£28,646	£33,992	£38,359	£37,821	£34,868	£37,644	£36,716	-	£35,093
	2014	£34,355	£33,262	£32,828	£34,355	£34,355	£34,355	£34,355	£34,355	£34,355	£34,355	£34,355	-	£34,355
Building and civil engineering technicians	2015	-	-	-	-	-	-	-	£29,048	£24,065	-	£41,259	-	£28,605
	2014	£30,610	-	£32,019	£30,610	£30,610	£30,610	£30,610	£30,610	£30,610	£30,610	£30,610	-	£30,610
Science, engineering and production technicians n.e.c.	2015	£24,484	£24,831	£26,518	£28,057	£26,374	£25,445	£31,624	£28,005	£26,792	£25,332	£27,201	-	£26,969
	2014	£26,820	£24,512	£28,425	£26,820	£26,820	£26,820	£26,820	£26,820	£26,820	£26,820	£26,820	-	£26,820
Aircraft pilots and flight engineers	2015	-	£70,234	-	£77,435	-	£90,535	£94,380	£78,431	-	-	-	-	£86,342
	2014	£90,146	-	-	£90,146	£90,146	£90,146	£90,146	£90,146	£90,146	£90,146	£90,146	-	£90,146
Air-conditioning and refrigeration engineers	2015	-	£26,389	£30,515	-	£30,479	£28,040	-	£34,587	-	-	£39,209	-	£31,251
	2014	£30,652	£29,851	-	£30,652	£30,652	£30,652	£30,652	£30,652	£30,652	£30,652	£30,652	-	£30,652
Telecommunications engineers	2015	£30,700	£32,711	£36,853	£36,335	£30,731	£31,075	£35,324	£33,293	£31,358	£32,737	£35,046	-	£33,267
	2014	£32,320	£29,924	£32,151	£32,320	£32,320	£32,320	£32,320	£32,320	£32,320	£32,320	£32,320	-	£32,320
TV, video and audio engineers	2015	-	-	-	-	-	-	£23,058	£26,372	-	-	£31,729	-	£28,475
	2014	£27,361	-	£31,889	£27,361	£27,361	£27,361	£27,361	£27,361	£27,361	£27,361	£27,361	-	£27,361
IT engineers	2015	-	£24,738	£21,502	-	£26,597	£32,175	£30,656	£30,270	£23,884	-	£27,855	-	£28,039
	2014	£25,934	-	-	£25,934	£25,934	£25,934	£25,934	£25,934	£25,934	£25,934	£25,934	-	£25,934
Plumbers and heating and ventilating engineers	2015	£26,312	£24,589	£29,301	£27,980	£28,586	£29,581	£32,626	£28,989	£28,849	£21,747	£29,483	-	£28,153
	2014	£27,330	£24,716	£23,294	£27,330	£27,330	£27,330	£27,330	£27,330	£27,330	£27,330	£27,330	-	£27,330
Entire workforce covered	**2015**	**£24,748**	**£25,104**	**£24,050**	**£24,248**	**£24,889**	**£25,882**	**£40,305**	**£28,805**	**£24,428**	**£23,304**	**£26,413**	**£23,643**	**£27,607**
	2014	**£23,644**	**£24,608**	**£23,564**	**£24,172**	**£24,102**	**£25,704**	**£41,095**	**£28,198**	**£23,913**	**£22,877**	**£25,584**	**£21,616**	**£27,271**

Source: ONS – Annual Survey of Hours and Earnings

as did design engineers in London. At technician level, engineering technicians earned relatively strongly in the south and east of England, as well as in Wales and Scotland.

The variations in the data by region and occupational role reflect the complexity of the local labour market and varying needs for high-level engineering-related skills by different organisations across the UK. However, taking into account the high cost of living in the south east of England, engineering occupations offer strong earnings potential right across the UK.

9.5 Salary survey trends

A number of the salary surveys carried out by either Professional Engineering Institutions or others in the sector have ceased in recent years. The last survey of the salaries of professionally-registered engineers and technicians was carried out in 2013, the results of which were quoted in the 2015 edition of this publication. This gave a median salary for chartered engineers of £60,000, incorporated engineers of £45,000 and engineering technicians of £37,000.

Although at a much more modest scale, a salary survey conducted by *The Engineer* in 2016 suggested average earnings across engineering to be around £45,500.[9.23] This is likely to have included engineers (and some other occupational roles) at professional, associate professional and technician level, within a range of industrial sectors. Most respondents were in their 40s, and one third were professionally registered. However, its figures offer a complementary insight into relative earnings across different industry sectors in engineering and STEM (Table 9.6). It found the highest average salaries currently to be in the oil and gas sector (at over £51,000), with averages in several other engineering sectors quite closely clustered around the aggregate engineering figure, in the range £43,000 to £46,000. For comparison, it highlighted a similar average for the chemical/pharmaceutical industry and it was only slightly higher for banking and accounting.

Within its total sample of around 3,700, the number of female respondents was understandably modest but suggested earnings for women were around £10,000 lower, which it explained by suggesting that respondents tended to be in less senior roles. A further interesting element to its research was that over 85% of respondents reported that they would be content to remain in the engineering sector for a further five or more years, which is relatively high for responses to a question of this nature.

Table 9.6: Average salary of respondents to *The Engineer* 2016 salary survey, by STEM industrial sector

Sector		Mean salary £
Engineering		£45,367
	Oil and gas	£51,370
	Other	£50,132
	Automotive	£45,879
	Telecoms/electronic	£44,898
	Aerospace	£44,580
	Rail/civil/structural	£43,181
Chemical/ pharmaceutical		£47,506
Banking		£48,590
Accounting		£50,606
Financial services		£44,818

Source: Centaur Publications (The Engineer)

9.6 The state of engineering recruitment

By Ewan Greig, Roevin Engineering Recruitment

As with many recruitment sectors, 2016 has been a fairly turbulent year for engineering recruitment. Many employers continue to be unsure exactly what the future may hold for them and, as such, have been relatively unwilling to commit to long-term investments, which can include permanent appointments. Some of this uncertainty can be explained by the run-up to the UK referendum, and the result of the vote to leave the European Union guarantees a further period of uncertainty. In the background, a continually-fluctuating oil price, the collapse of British Steel and, more recently, a dramatic decline in the value of the pound are certainly not helping the recruitment market.

In the month before the referendum, the Association of Professional Staffing Companies (APSCo) reported that permanent vacancies across all professional staffing sectors (including engineering) were broadly at the same level as a year earlier. Ann Swain, APSCo's CEO, said:

The fact that permanent hiring has slowed consistently in the run up to the EU referendum means that this latest data is unsurprising. However, although there has been no increase in permanent roles year-on-year, vacancies for contractors rose marginally, a trend which we expect to continue amid the ongoing market uncertainty.

9.23 The Engineer: *The Engineer Salary Survey 2016*, June 2016. https://www.theengineer.co.uk/the-engineer-salary-survey-2016/

Manufacturing is still king

The manufacturing sector continues to account for around half of all vacancies in the engineering market, as it has done for at least the last four years. UK manufacturing is the 11th largest manufacturing sector in the world and accounts for over 10% of the UK's GDP. There seems to be no reason to suspect that this will change in the near future, although the changing nature of Britain's relationship with the European Union could potentially affect the industry in the longer term.

However, this is not to say that manufacturing jobs in this sector are not changing. The manufacturing sector has seen employment fall by more than 60% in the last 40 years, but there are still more than 2.6 million people employed in manufacturing and increasingly they are in highly skilled roles. The UK Commission for Employment and Skills believes that advanced manufacturing will grow in the coming years, especially in Western Europe. Some 29,000 advanced manufacturing enterprises already operate in the UK, and comprise nearly a quarter of the manufacturing sector. Areas such as 3D printing and plastic electronics are expected to see significant growth.

Automation is also a particular interest, with two-thirds of all UK manufacturing businesses committed to major automation projects within the next two years.

Current hot spots

Data we have collected by tracking online job vacancies over the last four years suggest that three other sectors have been experiencing increasing demand for engineering talent in recent years:

- Education;
- Transport and logistics;
- Construction.

Increasing demand in the education system is a really positive thing for the engineering industry – it is an illustration of the increased interest from students in studying the subject and a demonstration of the drive by government to close the skills gap in engineering. It also gives engineers another option to pursue, or something to look at later in their careers.

The construction sector is interesting. This is a sector that was expected to suffer badly from the result of the EU referendum. Output fell for the first few months following the result but far more slowly than many had predicted. Output for August was in fact only 49.2 (on a scale where 50 represents no change) according to the Purchasing Managers Index compiled by Markit and the Chartered Institute of Procurement and Supply.

Tim Moore, senior economist at Markit, acknowledged there were widespread reports of a slowing in progress on planned developments but Mike Chappell of Lloyds Bank said that:

A number of the bigger players in the sector report robust results with a relatively upbeat outlook, suggesting there may have been less negative impact from the EU referendum result than was originally feared, at least at the top of the market.

What is unchanged is the fact that the UK still has a chronic lack of housing, especially in the South East. Meanwhile the National Association of Estate Agents believes that property prices will only be £1,000 lower on average by the end of the year, which would suggest the construction industry will not be seeing a dramatic reduction in its requirements for labour relating to domestic property. Overall, the longer-term future for the construction sector may well be as constrained by a lack of skills as much as by lack of demand. The second quarter of 2016 saw the highest number of job vacancies advertised in construction for nearly three years.

Increased demand for talent in infrastructure

One the clearest trends from the recent data has been an increasing demand for civil engineers. A degree in civil engineering is a now a requirement in up to 15% of vacancies (which is up from 9% in 2012). As a job title this is now the third most demanded role, accounting for more than one in six vacancies (compared with one in nine in 2012). As a skill set, civil engineering is now ranked inside the top ten most requested skills clusters in the industry.

This demand is being driven by increased spending on infrastructure and construction in the UK. Projects such as HS2 and Crossrail are only two examples. In November 2015, then Chancellor, George Osborne, announced that investment in major transport projects would increase by 50% over the course of this parliament, calling it "the biggest increase in a generation" on road and rail investment. This has resulted in an upturn in the demand for talent in the transport and logistics areas.

There may be additional impact from major transport powers being devolved to six mayor-led local authorities. Greater Manchester will be the first to hold elections in 2017, followed by Sheffield, then North East, Tees Valley, West Midlands and Liverpool.

A new breed of engineer needed

In this day and age, an engineer's role is far wider than just solving the technical problem in front of them. Engineers need to be team players and leaders, collaborators and innovators, salesmen and relationship builders.

The top four most frequently requested skills clusters, over the last two years, have been wider business skills rather than technical competences:

- Communication and coordination;
- Project and process flow skills;
- Business environment skills;
- Problem-solving.

Gary Meechan, managing director of Roevin explains:

Companies are always looking to work smarter and more productively, to gain competitive edge over their peers and, increasingly, engineers are being expected to drive this innovation. Even customer service and marketing skills are now in the top 20 most requested for engineers.

Green skills are another area that has been on the increase. The 'Green Skills' cluster (pollution reduction, removal and remediation) has been consistently inside the top 20 most frequently requested over the last four years, appearing in more than 5% of all job advertisements. Environmental technology is now a desired degree subject for 2% of all job adverts – more than mathematics or aeronautical engineering. With renewable energy anticipated to provide 20-25% of the UK's electricity generation capacity by 2020, these skill sets will continue to be in demand.

Not everything is rosy

However, the energy sector as a whole in the UK has certainly not been a growth market for employment in recent years. Oil and gas have struggled as the UK has been unable to compete with the US fracking revolution, and the current very low price of oil is making North Sea extraction unworkable. This has caused a reduction in demand for design and development roles in these areas, demand which is unlikely to return until oil prices rise again and are consistently over $60 per barrel. The Aberdeen and Grampian Chamber of Commerce Oil and Gas Survey has predicted 65,000 job losses during 2016.

The reduction in subsidies for certain renewable energies, such as solar power and onshore wind, has affected profitability in the renewables arena. Nuclear power does present something of an opportunity in the UK over the coming years, as new nuclear power plants are due to come onstream by 2030, when almost half of the existing nuclear capacity will cease. Critics suggest that Hinkley Point C is set to become the most expensive man-made structure in history. However, this was nearly derailed by political pressure recently, so the nuclear labour market is not guaranteed to continue growing.

Part 3 – Engineering in Employment
10 Employment and skills supply and demand projections

Key points

The changing shape of the workforce

New technology and a global marketplace are shifting the balance of industry. In turn, this means that we need more people with high-level skills to work in technology-intensive sectors, and more with low-level skills to work in the care and some other service sectors, at the expense of those with mid-level skills.

This trend is being heightened by new industries – some of which scarcely yet exist – emerging from technological and knowledge-based opportunities.

The evidence tells us, however, that the right skills are in short supply in key sectors of the UK engineering industry. The expanding sectors of construction and ICT are worst affected by skills shortages. Manufacturing is also feeling the effects, despite the total size of the industry contracting thanks to smart automation.

Demand and skills shortages

The need for skills will only grow. The 2014-2024 update to *Working Futures* predicts an annual growth in total employment of 0.5%. A bespoke extension to *Working Futures* for the engineering sector projects an average demand for 265,000 jobs in engineering enterprises per year, of which around 186,000 will be in engineering occupations. This is based on replacing workers as they retire or become economically inactive for other reasons (replacement demand), and expansion demand as activity grows (expansion demand).

- The total size of level 3 employment will shrink, but there will be significant replacement demand of around 57,000 entrants per year;
- At level 4 and higher, the annual requirement for engineering occupations is expected to be just over 101,000 annually.

The demand will be particularly acute in construction, but also strong across the science and engineering, ICT and manufacturing sectors. Demand is expected to be highest in London and the South East of England, although there will be net demand in all UK nations and regions.

Projected supply

EngineeringUK has modelled the supply of entrants to engineering enterprises with level 4+ skills through higher education and high-level apprenticeships. We project that there will be around 41,000 entrants of UK nationality annually.

Graduates from the EU and other nations could potentially add a further 40,000 to the engineering supply. This would give a total supply of workers with high level skills of just over 81,000. (This projection assumes that similar numbers of international students will continue to study in the UK and continue to be eligible to work in engineering in the UK.)

Even with these assumptions, the projected supply will fall short of demand by around 20,000 per year. If the supply were to be limited to only UK-domiciles at level 4+, it would fall far below the projected requirement.

The current supply of postgraduate-level skills in engineering and computing is highly dependent on international graduates studying in the UK – more so than any other major higher education discipline. This represents a distinct vulnerability.

Although the implications of the UK's intention to leave the EU have not been modelled, it seems likely that this will affect both sides of the supply/demand equation, potentially with different rates of change.

On the supply side, any tightening of immigration policy or reduction to the perceived attractiveness of studying and working in the UK would have immediate detrimental impact on the supply of key skills. In turn, this will limit the engineering sector's ability to contribute to the UK economy.

Protecting the supply

Therefore we must protect the flow of international talent. We must also expand the UK supply pipeline and make engineering more attractive so that more people in the pipeline choose to enter the industry.

We should also consider initiatives that could contribute towards fulfilling the demand for engineering skills and labour. For instance, we must find ways to improve retention in the sector and make it easier for people to move between sub-disciplines and occupations. Nor should we forget the opportunity and need to reskill or upskill entrants to engineering from other workforces.

10.1 Context

10.1.1 The hourglass economy

The profile of the UK labour force is changing. There has been a progressive reduction in traditional middle-level skilled jobs and expansion in highly-skilled roles, along with more roles in service and care sectors that require low levels of qualifications. This trend has been dubbed the 'hourglass economy', as depicted in Figure 10.1.

In the engineering sector, this trend reinforces the increasing importance of having a highly-skilled workforce, both in terms of entrants to the sector and the need to upskill existing employees.

In manufacturing, smart automation will boost productivity but, at the same time, reduce the number of people required. For the first time, there could be fewer people working in the manufacturing sector than in construction.[10.2]

Meanwhile, digital technologies are expected to enhance efficiency and reduce headcounts while maintaining quality in many service sectors. This is especially true of the public sector, which is undergoing a productivity drive resulting from austerity measures. However, these areas of decreasing employment will be outweighed by continued strong job creation in health, education, business services and professional, scientific and technical activities across a range of sectors. Much of the expected growth in the health sector will be driven by the increasing health demands of the ageing population. The NHS push towards more community healthcare will also adjust employment patterns in both the health and social care sectors.

10.1.2 New industries

Changes in employment patterns will not be restricted to shifts in existing industries. A whole range of new industries are forecast to develop over the coming decades, impacting heavily on requirements for highly-skilled labour, and especially STEM skills. The UK Commission for Employment and Skills notes that advances in robotics and additive manufacturing (of which 3D printing is an example) are already leading to an increase in the demand for highly-skilled, IT-literate staff to work in the UK's advanced manufacturing sector.[10.3] The global advanced manufacturing market is forecast to reach £750 billion in 2020 – almost double its current size.

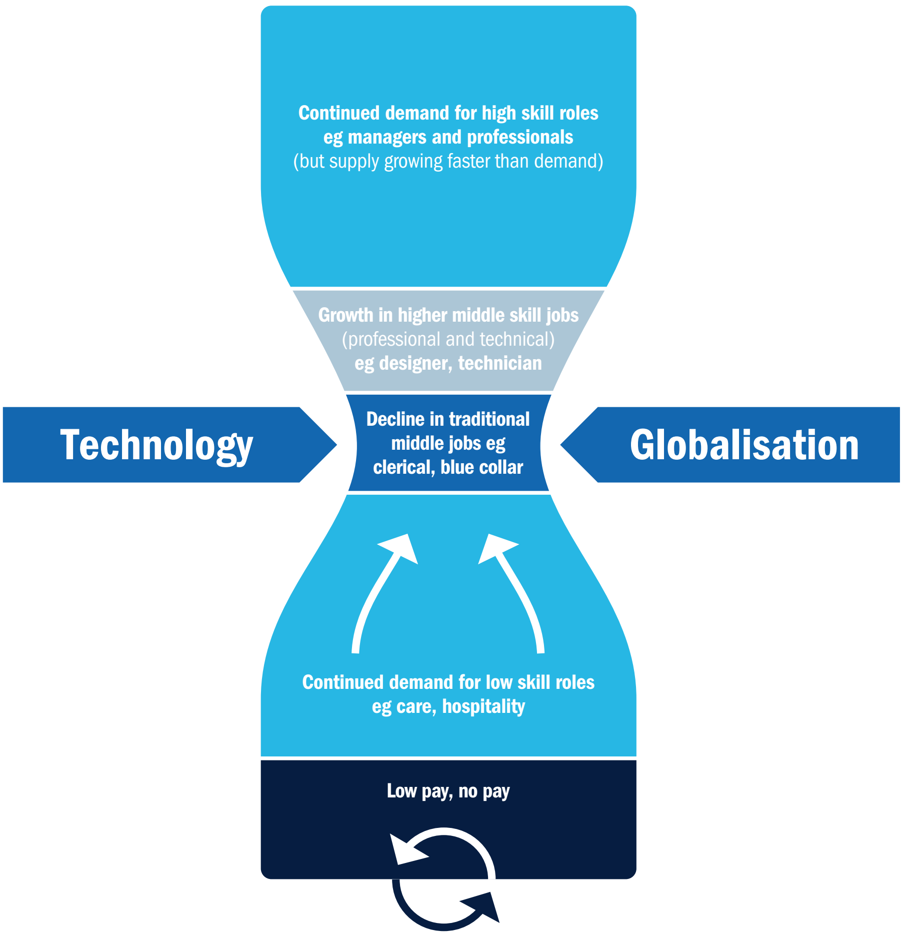
Demand for high-level computing and IT skills will also grow due to the increasing adoption of robotics in areas that were traditionally served by human labour. Along with advanced manufacturing, robotics will be used in a range of service industries such as healthcare (to support or even conduct surgery, and enhance patient care) and transport, as we witness the rapid development of autonomous vehicles for transporting passengers and goods.

A further computing-related area expected to experience dramatic growth in coming years is 'big data'. Large, complex datasets can reveal patterns and associations relating to consumer and economic behaviour, but traditional data processing methods are inadequate for analysing them. Much IT investment is currently going into managing and maintaining these datasets. As long ago as 2012, Gartner predicted demand for 4 million skilled workers in data and analytics roles worldwide by 2015, only one third of which were likely to be filled.[10.4] The emerging role of the data scientist is intended to fill this gap, and university courses are springing up in data science and analytics. Expectations for market growth in this area are commonly more than 20% annually.

Arguably, the technological development most likely to disrupt UK and global labour markets over the coming decades is artificial intelligence (AI). AI has been used for a decade, most visibly in the financial sector, to predict trends in stocks. In the near future, it is expected that its use will expand rapidly to fields such as medical diagnosis, education and gaming.[10.5]

In speculating about the nature of life, work and the economy in future decades, futurologists make frequent reference to large numbers of people working in 'jobs that haven't been thought of yet'. Speculation aside, it is true that the pace of change through technological development – and especially the role of data and information – is increasing fast. It seems likely that becoming highly skilled, retaining and refining those skills, and being able to learn new ones may be important for many in terms of ongoing employability.

Figure 10.1: Future shape of the labour market[10.1]



Source: UKCES

10.1 UKCES: *The labour market story:* an overview, July 2014. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/343448/The_Labour_Market_Story-_An_Overview.pdf
10.2 PwC: *UK economic outlook March 2016*. https://www.pwc.co.uk/assets/pdf/ukeo/ukeo-sectoral-employment-march-2016.pdf **10.3** UKCES: *Rise of the machines causing skills shortages, new report finds* (press release), June 2015. https://www.gov.uk/government/news/rise-of-the-machines-causing-skills-shortages-new-report-finds **10.4** Gartner: *Gartner Says Big Data Creates Big Jobs: 4.4 Million IT Jobs Globally to Support Big Data By 2015* (press release), October 2012. http://www.gartner.com/newsroom/id/2207915 **10.5** UKCES: *The future of work: jobs and skills in 2030*, February 2014. https://www.gov.uk/government/publications/jobs-and-skills-in-2030

10.1.3 Hot spots – key areas of skills shortages

According to the Skills Shortage Vacancies list published by the UK Commission for Employment and Skills (UKCES), businesses have been reporting major skill shortages in sectors such as manufacturing, engineering, utilities, construction and IT in recent years. A Skills Shortage Vacancy occurs when an employer is unable to find workers with the skills or experience that they require. Three years ago, it reported that over 40% of vacancies for professionals working in science, research, engineering and technology were hard to fill due to skills shortages and labour market conditions. This figure was almost twice as large as the rate across all occupations combined, making the STEM sector the worst affected occupational groups.[10.6]

However, it should be noted that a hard-to-fill vacancy may not necessarily be due to an absolute shortage of skills in the labour force. It could result from an employer being unable to recruit the skilled workers that do exist due to factors such as competition from other employers, geographical location or mismatches of skills and requirements. Different employers attribute different issues to their underlying inability to recruit the graduates they need. Some relate this to insufficient technical knowledge. Increasingly, however, the lack of 'employability skills' and/or relevant work experience seems to be hindering the recruitment of many graduates. This was highlighted in the Wakeham review:

The lack of clear, accessible and detailed data on the nature of specific employer demands for STEM skills has been a constant challenge for the review and we recommend that there is more that employers should do to work proactively with education providers to understand and set out their skills requirements at sector-wide levels.[10.7]

Engineering employment presents a paradox. Graduate skills shortages in engineering and computing are particularly high, and yet unemployment rates for recent graduates in these subjects – especially computer science – are higher than for other subjects. A lack of employability skills could go some way to explaining this paradox.

Notwithstanding this issue, UKCES also noted in its 2015 survey that, while the density of skills shortages across the UK changed little between 2013 and 2015, the distribution by sector was changing. In 2013, the highest skills shortage density was in manufacturing. By 2015, this had shifted to the energy/utilities and construction sectors (both at 35%).[10.8]

In construction, the number of Skills Shortage Vacancies had more than doubled since 2013, rising from 5,000 to 12,000. This had outpaced the overall growth of vacancies in the sector based on increased recruitment activity. This indicates that construction employers were facing significant, and increasing, challenges in recruiting sufficiently skilled labour.

According to a survey conducted by the Confederation of British Industry (CBI), close to half of businesses (42%) would like to see an increase in the number of science, technology, engineering and maths (STEM) graduates.[10.9] Furthermore, in research conducted by the Institution of Engineering and Technology, 59% of engineering employers expressed concerned that a shortage of engineers posed a threat to their business.[10.10]

This is reflected in results from the 2016 *CBI/Pearson Education and Skills Survey* indicating that most firms in construction – and especially engineering, science and technology – anticipate a need to recruit more people with higher skills, but the majority are not confident in their ability to access those skills. They are, however, more confident in relation to lower skills levels.[10.11] A summary of its findings is given in Chapter 11.

The impacts of having hard-to-fill or Skills Shortage Vacancies can be many and varied, according to the UKCES *Employer Skills Survey*, with engineering enterprises suffering more than others. Table 10.1 shows that the biggest impact of unfilled vacancies is an increased workload for existing staff. This problem is even more marked in engineering, presumably due to the high skills required in much of the work. Unfilled vacancies can create difficulties meeting customer needs (an implication for more than half of engineering respondents to the survey). Crucially for a technology-based sector like engineering, there were also implications in terms of delays to new products or services, as well as the risk of losing business to competitors. A relatively common response (for 35% of engineering enterprises) was to outsource work, which immediately has implications for skill development and retention in the organisation.

10.2 Labour force projections and demand for skills

10.2.1 Total workforce

Working Futures 2014-2024 is a comprehensive and detailed model of the UK labour market, produced by the Warwick Institute for Employment Research and Cambridge Econometrics for the UK Commission for Employment and Skills.[10.12] It projects the future size and shape of the labour market by considering employment prospects by industrial sector, occupation, qualification level, gender and employment status.

The 2014-2024 projection suggests that over this ten-year period there will be 13 million job

Table 10.1: Most common implications of hard-to-fill vacancies on enterprises

	All enterprises		All engineering enterprises	
	Count	Proportion	Count	Proportion
Increase workload for other staff	74,817	83.4%	16,153	87.0%
Have difficulties meeting customer services objectives	42,139	47.0%	10,414	56.1%
Delay developing new products or services	36,763	41.0%	8,963	48.3%
Lose business or orders to competitors	36,251	40.4%	8,421	45.4%
Experience increased operating costs	36,003	40.1%	8,309	44.8%
Have difficulties introducing new working practices	31,720	35.3%	5,712	30.8%
Have difficulties meeting quality standards	29,826	33.2%	5,578	30.1%
Outsource work	24,707	27.5%	6,538	35.2%
Withdraw from offering certain products or services altogether	20,860	23.2%	4,377	23.6%
Have difficulties introducing technological change	17,862	19.9%	4,789	25.8%

Source: Bespoke analysis of UKCES Employer Skills Survey data

10.6 UKCES: *Reviewing the requirement for high level STEM skills*, July 2015. https://www.gov.uk/government/publications/high-level-stem-skills-requirements-in-the-uk-labour-market **10.7** BIS: *Wakeham Review of STEM Degree Provision and Graduate Employability*, 2016. https://www.gov.uk/government/publications/stem-degree-provision-and-graduate-employability-wakeham-review **10.8** UKCES: *Employer skills survey 2015 – UK results*, May 2016. https://www.gov.uk/government/publications/ukces-employer-skills-survey-2015-uk-report **10.9** CBI: CBI/Pearson *Education and skills survey 2014, gateway to growth*, 2014. http://www.ucml.ac.uk/sites/default/files/shapingthefuture/101/gateway-to-growth.pdf **10.10** p4. Institution of Engineering and Technology: *Skills and demands in industry*, 2014. http://www.theiet.org/factfiles/education/skills2014-page.cfm **10.11** CBI: *CBI/Pearson education and skills survey 2016 – The right combination*, July 2016. http://www.cbi.org.uk/cbi-prod/assets/File/pdf/cbi-education-and-skills-survey2016.pdf **10.12** UKCES: *Working Futures 2014-2024*, March 2016. https://www.gov.uk/government/publications/uk-labour-market-projections-2014-to-2024 openings created by those who leave the labour market (replacement demand), together with 1.8 million openings from newly created jobs (expansion demand). This represents annual growth of around 0.5% in the number of jobs in the UK. It is expected that, across all sectors combined, women will take most of the additional jobs, particularly full-time, while the level of self-employment is actually predicted to fall.

It should be noted that replacement demand is a result of all those who leave the labour market – not purely due to retirement (or death), but also for other reasons such as maternity, emigration, incapacity, redundancy and unemployment.

Working Futures 2014-2024 also predicts that manufacturing's share of total employment will fall from its current 7.8% to 6.7% by 2024, although it will nearly maintain its share of UK output (at about 9.5%) thanks to increased levels of automation. However, even where a sector or occupation declines in scale, there continues to be some replacement demand.

Table 10.2 suggests that 11 occupations are projected to grow by at least 10% over the next 10 years. These include several key service occupations and a range of professional occupations, as well as corporate managers and directors. The professional occupational roles expected to grow by this extent include those in science, research, engineering and technology along with health, teaching, business, media and public services. Skilled construction and building trades occupations and science, engineering and technology associate professional roles are also expected to grow at or above the overall rate of growth in employment.

In contrast, several occupations are expected to shrink over this period, including administrative and secretarial occupations; textiles, printing and other skilled trades; skilled metal, electrical and electronic trades; and process, plant and machine operatives. Amongst the latter groups, men are particularly likely to be affected.

Table 10.2 is also useful in identifying occupations where particularly high numbers of employees will be needed to fulfil both replacement and expansion demand. Some engineering-related occupations will need to recruit heavily to meet replacement and expansion demand in the next 10 years.

Table 10.2: Expansion and replacement demand for all industries, by occupation (2014-2024) – UK[10.13, 10.14]

	Base employment level 2014	Expansion demand	Proportion of base employment	Replacement demand (retirements and mortality)	Proportion of base employment	Net requirement	Proportion of base employment
Customer service occupations	586,000	104,000	17.8%	206,000	35.2%	310,000	53.0%
Corporate managers and directors	2,194,000	381,000	17.4%	841,000	38.3%	1,222,000	55.7%
Caring personal service occupations	2,464,000	394,000	16.0%	1,080,000	43.8%	1,473,000	59.8%
Business, media and public service professionals	1,763,000	279,000	15.8%	764,000	43.4%	1,043,000	59.2%
Health and social care associate professionals	489,000	77,000	15.7%	191,000	39.1%	267,000	54.8%
Health professionals	1,435,000	207,000	14.5%	588,000	40.9%	765,000	55.4%
Business and public service associate professionals	2,459,000	349,000	14.2%	947,000	38.5%	1,295,000	52.7%
Culture, media and sports occupations	738,000	95,000	12.9%	318,000	43.1%	413,000	56.0%
Science, research, engineering and technology professionals	1,712,000	218,000	12.7%	529,000	30.9%	747,000	43.6%
Other managers and proprietors	1,110,000	118,000	10.6%	548,000	49.4%	666,000	60.0%
Teaching and educational professionals	1,686,000	171,000	10.1%	750,000	44.5%	920,000	54.6%
Skilled construction and building trades	1,176,000	76,000	6.5%	399,000	34.0%	476,000	40.5%
Science, engineering and technology associate professional	575,000	30,000	5.3%	176,000	30.6%	206,000	35.9%
Elementary administration and service occupations	3,068,000	114,000	3.7%	1,254,000	40.9%	1,368,000	44.6%
Skilled agricultural and related trades	419,000	13,000	3.2%	236,000	56.4%	249,000	59.6%
Leisure, travel and related personal service occupations	670,000	15,000	2.3%	307,000	45.8%	322,000	48.1%
Transport and mobile machine drivers and operatives	1,163,000	23,000	2.0%	509,000	43.8%	532,000	45.8%
Elementary trades and related occupations	584,000	6,000	1.0%	200,000	34.3%	206,000	35.2%
Protective service occupations	376,000	-13,000	-3.4%	92,000	24.4%	79,000	21.0%
Administrative occupations	2,762,000	-113,000	-4.1%	1,156,000	41.8%	1,042,000	37.7%
Sales occupations	2,014,000	-101,000	-5.0%	740,000	36.8%	639,000	31.7%
Textiles, printing and other skilled trades	760,000	-68,000	-8.9%	290,000	38.2%	222,000	29.2%
Skilled metal, electrical and electronic trades	1,258,000	-119,000	-9.5%	374,000	29.8%	255,000	20.3%
Process, plant and machine operatives	904,000	-154,000	-17.1%	266,000	29.5%	112,000	12.4%
Secretarial and related occupations	804,000	-276,000	-34.4%	348,000	43.3%	72,000	9.0%
All occupations	33,167,000	1,825,000	5.5%	13,110,000	39.5%	14,936,000	45.0%

Source: Working Futures 2014-2024

10.13 Numbers may not sum due to rounding errors 10.14 Occupational and geographical mobility are assumed to be zero in these estimates

Science, research, engineering and technology professionals will need to expand their workforce by 43.6%. Skilled construction and building trades will need 40.5% more workers, and the science, engineering and technology associate professional workforce will need to increase by 35.9%.

For some occupations, the need to expand is higher still. For instance, health professionals and teachers will both need to recruit at the level of 55% of the current workforce, and at 60% for caring occupations. These projections clearly demonstrate the expected hollowing out of the middle levels of employment in favour of both highly-skilled and managerial roles and relatively low-skilled service-based roles.

10.2.2 Projections of demand for engineering enterprises

For this projection, the University of Warwick's Institute for Employment Research has created a bespoke extension of *Working Futures 2014-2024* for engineering enterprises. The analysis shows that engineering companies are now projected to see 2.65 million job openings across a diverse range of disciplines between 2014 and 2024. This is just under 90,000 higher than in the last (2012-2022) projection, and represents 17.7% of all expected job openings across all industries by 2024. This is equivalent to around 46% of the current engineering enterprise workforce (about 5.7 million). Of these 2.65 million job openings, around 2.42 million will be to replace workers who are leaving the workforce (replacement demand), while the remaining 234,000 will be new jobs (expansion demand).

However, it is important to note that not everyone working in an engineering company will be employed in an engineering role. What's more, not all engineering roles will require the same level of skills.

Table 10.3 provides a breakdown of the demand for jobs across the major occupation groups. These major groups are then broken down by the sub-groups that we regard as most likely to need engineering skills and the level at which they are needed. It is considered that those employed in engineering companies as corporate managers and directors, other managers and proprietors, and science, research and engineering technology professionals will need engineering skills at level 4 or above.

Furthermore, we calculate that a proportion of those employed as science, engineering and technology associate professionals, and business and public service associate professionals, will need engineering skills at level 4 or above. The number of people employed in these professions was calculated from the proportion of people working in them in 2014 who had a level 4+ qualification.

The demand for employees with level 3 engineering skills was calculated on the basis of those working in skilled trades occupations such as the metal, electrical and electronic trades, the construction and building trade, and also textiles, printing and other skilled trades. A proportion of those employed as science, engineering and technology associate professionals and business and public service associate professionals was also assumed to need engineering skills at level 3+. These were calculated from the percentage of people working in these occupations in 2014 who had a level 3 qualification.

Table 10.3 estimates that 234,000 new jobs will become available in engineering enterprises by 2024 thanks to expansion (expansion demand), while 2,415,800 will become available to compensate for people leaving the existing workforce (replacement demand). Assuming that these demands are uniformly distributed across the ten years, this gives a total demand for workers in the engineering sector of just under 265,000 per year.

When non-engineering roles are filtered out of this overall figure, there is a total replacement demand for engineering skills at all levels of 1,732,000 and a total expansion demand of just under 125,000 for all skill levels. Averaged out per year, this is a total demand of just under 186,000 workers in an engineering role per year.

For engineers with level 3 skills, the projections actually indicate a fall in expansion demand, with a decline of nearly 39,000 new jobs between 2014 and 2024. This is consistent with predictions that the number of mid-level jobs will reduce in the coming years in favour of lower- and higher-skilled occupations. However, the replacement demand at level 3 is estimated at nearly 605,000, which will result in a net annual requirement of just under 57,000 workers with engineering skills at level 3.

At level 4 and above, expansion demand is estimated at 260,000 between 2014 and 2024, with replacement demand at just over 750,000. This results in an annual requirement for level 4+ skills of 101,223.

It is worth noting that the projected expansion demand for level 4 positions is higher than that projected for employees in engineering enterprises across all skill levels and occupations, because of the decline in the number of new jobs at level 3 and below. This is a reflection of the progressive upskilling of the engineering sector.

Back to Contents

Table 10.3: Expansion and replacement demand in the engineering sector, by occupation and skills required (2014-2024) – UK

	Major group	Engineering skills sub-group		Expansion by 2024	Replacement by 2024	Total requirement by 2024	Annual requirement
Occupations requiring skills and experience equivalent to level 4+	**Managers and senior officials**			**111,500**	**305,700**	**417,200**	**41,720**
		11. Corporate managers and directors		98,500	242,100	340,600	34,060
		12. Other managers and proprietors		13,000	63,600	76,600	7,660
	Professonal occupations			**168,800**	**466,500**	**635,300**	**63,530**
		21. Science, research and engineering and technology professionals		92,900	259,000	351,900	35,190
Occupations requiring either level 4+ or level 3 skills and experience	**Associate professional occupations**			**95,600**	**350,200**	**445,800**	**44,580**
		31. Science, engineering and technology associate professionals		13,500	76,800	90,300	9,030
		31a. % working with level 4 qualifications or above	66.6%	8,991	51,149	60,140	6,014
		31b. % working with level 3 qualifications or below	33.4%	4,509	25,651	30,160	3,016
		35. Business and public service associate professionals		65,400	188,400	253,800	25,380
		35a. % working with level 4 qualifications or above	72.1%	47,153	135,836	182,990	18,299
		35b. % working with level 3 qualifications or below	27.9%	18,247	52,564	70,810	7,081
Occupations requiring level 3 skills and experience	**Administrative, clerical and secretarial occupations**			**-31,300**	**241,900**	**210,600**	**21,060**
	Skilled trades occupations			**-44,400**	**559,000**	**514,600**	**51,460**
		52. Skilled metal, electrical and electronic trades		-83,700	229,100	145,400	14,540
		53. Skilled construction and building trades		52,800	245,500	298,300	29,830
		54. Textiles, printing and other skilled trades		-30,600	52,000	21,400	2,140
	Personal service occupations			**17,900**	**34,100**	**52,000**	**5,200**
	Sales and customer service occupations			**13,100**	**81,700**	**94,800**	**9,480**
Occupations requiring level 2 skills and experience	**Transport and machine operatives**			**-88,700**	**242,300**	**153,600**	**15,360**
		81. Process, plant and machine operatives		-114,500	160,600	46,100	4,610
		82. Transport and mobile machine drivers and operatives		25,800	81,700	107,500	10,750
	Elementary trades and related occupations			**-8,300**	**133,500**	**125,200**	**12,520**
		91. Elementary trades and related occupations		-3,000	58,100	55,100	5,510
		92. Elementary administration and service occupations		-5,300	75,400	70,100	7,010
Total engineering company demand				**234,200**	**2,414,900**	**2,649,100**	**264,910**
Total demand for engineering skills	**All**			**124,800**	**1,732,300**	**1,857,100**	**185,710**
	Equivalent level 4 or above	(sub groups: 11, 12, 21. 31a, 35a)		260,544	751,685	1,012,230	101,223
	Equivalent level 3	(sub groups: 31b, 35b, 52, 53, 54)		-38,744	604,815	566,070	56,607

Source: Working Futures 2014-2024 engineering extension

Table 10.4 uses these projections to paint a picture of likely recruitment requirements in the UK nations and regions. This suggests that over 85% of job vacancies in engineering enterprises, and almost equally for the jobs most likely to need engineering skills, will be in England. In England, highest demand for jobs in engineering enterprises is expected to be in London and the South East (over 15% each). The South East is likely to have the largest requirement for jobs with engineering skills, followed by London. The lowest relative demands are expected to be in Northern Ireland, Wales and the North East of England.

Table 10.5 looks at the projections by main industry sectors and groups. Numerically, the most job openings within engineering enterprises are expected to be in construction, with strong expansion and replacement demand.

This is reflected by the most recent Working Futures model of the UK labour market. It anticipates that construction will be the fastest growing of the six major sectors on which it focuses, in terms of both output (3.1% growth in GVA per year) and employment (14% growth over 10 years).[10.15] Worryingly, however, the *CBI/ Pearson Education and Skills Survey 2016* reports that this sector has the greatest problem recruiting people with STEM skills for both technician- and graduate-level roles. (See Chapter 11 for a further perspective based on this report.)[10.16]

In contrast, although just under 24% of job openings in engineering enterprises will be in manufacturing, this sector's workforce will contract. Replacement demand will drive job openings. Working Futures comments that manufacturing will grow at a slower rate than the wider economy in the face of intense international competition, and that the fall in its total employment will be due largely to increased automation.

Requirement in the ICT sector is now projected to be 22% – a reduction from two years ago,[10.17] while the requirement in professional, scientific and technical activities has increased.

Table 10.4: Recruitment requirement in engineering enterprises, by nation/region (2014-2024) – UK

	Total requirement in engineering companies 2012-2022	Percentage of total requirement	Total requirement, for jobs most likely to require engineering skills, in engineering companies 2012-2022	Percentage of total requirement for jobs most likely to require engineering skills
North East	86,000	3.2%	60,000	3.2%
North West	260,000	9.8%	182,000	9.8%
Yorkshire and The Humber	190,000	7.2%	133,000	7.2%
East Midlands	204,000	7.7%	146,000	7.9%
West Midlands	224,000	8.5%	159,000	8.6%
East	246,000	9.3%	177,000	9.5%
London	413,000	15.6%	268,000	14.4%
South East	413,000	15.6%	299,000	16.1%
South West	236,000	8.9%	172,000	9.3%
England	2,274,000	85.8%	1,596,000	85.9%
Wales	104,000	3.9%	77,000	4.1%
Scotland	210,000	7.9%	141,000	7.6%
Northern Ireland	61,000	2.3%	43,000	2.3%
UK total	2,649,000	-	1,857,000	-

Source: Working Futures 2014-2024 bespoke analysis

Table 10.5: Recruitment requirements for engineering companies within the main industry groups (2014-2024) – UK

	Expansion demand by 2024	Replacement demand by 2024	Total requirement by 2024	Percentage of total requirement by 2024
Manufacturing	-241,000	867,000	626,000	23.6%
Construction	217,000	543,000	760,000	28.7%
Information and communication	136,000	446,000	582,000	22.0%
Professional, scientific and technical activities	96,000	305,000	401,000	15.1%
All engineering industries	234,000	2,415,000	2,649,000	-

Source: Working Futures 2014-2024 bespoke analysis

10.15 UKCES: *Working Futures 2014-2024*, March 2016. https://www.gov.uk/government/publications/uk-labour-market-projections-2014-to-2024 10.16 CBI: *The right combination – CBI/Pearson Education and Skills Survey 2016*, July 2016. http://www.cbi.org.uk/cbi-prod/assets/File/pdf/cbi-education-and-skills-survey2016.pdf 10.17 EngineeringUK: *The state of engineering 2016*, January 2016. http://www.engineeringuk.com/Research/

10.3 Supply analysis

The annual supply of people with level 3 engineering skills who are available to work in engineering occupations is taken to be the number of people who complete a level 3 engineering-related apprenticeship in the UK. On this basis, the most recent annual supply figure (2014/15) stands at 30,925, compared with 27,195 the previous year (Table 10.6).

Table 10.6: Number of level 3 apprenticeship achievements in engineering-related frameworks, by nation (2014/15)

	Number of achievements
England	23,780
Scotland	3,985
Wales	1,690
Northern Ireland	1,170
Total UK	**30,925**

Source: Data collated in Chapter 6 from Skills Funding Agency, Skills Development Scotland, Welsh Government, Department for Education and Learning Northern Ireland

Our approach to calculating the supply of those with level 4+ skills who are able to fill an engineering occupation is more complicated. Estimates are based on both an 'historic' approach and a 'potential' approach to supply. The former ('historic') is determined from our analysis of UK graduate destinations in 2014/15 (reported in Chapter 8): specifically, the proportion who entered an engineering occupation regarded to need level 4+ engineering-related skills. On the other hand, the 'potential' supply is based on everyone with level 4+ engineering-related skills who could have entered the workforce with these level 4+ engineering-related skills, ie based on a wider potential pool of appropriate graduates of all domiciles. Table 10.7 illustrates the results of a series of steps which comprise these calculations, which are laid out in pairs for the potential and historic supply, respectively.

The methodology and data used in the steps are as follows. (A discussion of the underlying assumptions, and their potential impact, and some sensitivity analysis follow in Section 10.3.1.):

- The first pair of columns records the total number of graduate qualifiers (by qualification level) in 2014/15, for all domiciles in column 1 (potential) and for UK domiciles only (historic) in column 2;
- The next pair of columns multiplies these numbers of qualifiers by the proportion of graduates reported to have entered employment (based on the DLHE survey results, of a sample of the graduate qualifiers, reported in Chapter 8) – this gives a calculation of the potential and historic numbers who enter employment;
- The third pair of columns use the proportion of graduates entering employment in engineering occupations (as a proportion of employed graduates) and applies this to the calculated numbers who enter employment of some kind – this produces the number of graduates who are employed in engineering occupations (again, the proportion is derived from the DLHE destinations results from 2014/15);
- The final calculation step is to multiply the number of graduates who are employed in engineering occupations by the proportion who are working there at graduate level, based on further DLHE destinations results – this gives a calculated number of graduates who are employed in engineering roles with skills equivalent to level 4.

The calculation steps are applied to different subjects of study at each level, including first degree, other undergraduate and postgraduate degrees, all based on the proportions given for the respective groups in the 2014/15 DLHE results.

As noted in Chapter 8 on graduate destinations, many graduates with degrees other than in engineering and technology enter employment in engineering-related roles. To account for this range of subjects, three tiers of graduate supply are used. The subjects have been tiered according to the number of graduates who have traditionally entered the engineering workforce:

- Tier 1 contains engineering and technology graduates at different levels of HE study, who have the highest rates of transition into engineering occupations;
- Tier 2 contains graduates from key STEM subject groups known to have a high proportion progressing into work in an engineering occupation;
- Tier 3 contains graduates from other subject groups known to have a low progression rate into engineering roles, although the rate is small, the total number of graduates to which it is applied is large, so the number entering engineering roles is significant.

As those from tiers 2 and 3 are less likely to work in an engineering-related occupation, more stringent criteria are applied to these groups when calculating their contribution to the potential supply. For tier 1, the potential supply is the number of qualifying graduates of all domiciles multiplied simply by the percentage who enter employment in the UK. This assumes all those with an engineering-related degree are potentially employable in an engineering-related role at graduate level.

For tier 2, the calculation is stricter and uses only the calculated number of qualifiers working in an engineering role, as this is considered a proxy for those contributing as engineers with level 4+ skills. Graduates in these subject groupings possess high-level STEM skills which are closely related to those required in engineering roles.

The strictest criteria are adopted for tier 3, where the proportion used is only those graduates who were known to be working at graduate level in an engineering-related role. This is an attempt to account for the fact that relatively few graduates from tier 3 have the skills required for engineering occupations at graduate level.

In summary, Table 10.7 provides the numbers of qualifying graduates and the calculated results for each step for each subject grouping and level of study. This results in figures for the potential and historic supply at each tier, in the last two columns. The overall results at tier and total level are summarised in Table 10.8.

Table 10.7: Supply of graduates with engineering-related skills at level 4+ (2014/15)[10.18]

		Number of qualifiers – all domiciles	Number of qualifiers – UK domicile	Calculated number employed	Calculated number employed UK	Calculated number employed in engineering role	Calculated employed in engineering role UK	Calculated employed in engineering role at graduate level	Calculated employed in engineering role at graduate level UK	Potential supply	Historic supply
Total tier 1		50,355	27,875	39,065	21,375	25,445	14,200	22,705	12,510	39,065	12,510
Engineering and technology	Other undergraduate	4,945	3,975	3,595	2,890	2,650	2,130	1,910	1,535	3,595	1,535
	Foundation degree	1,425	1,370	1,005	965	670	645	520	500	1,005	500
	First degree	25,380	17,380	19,440	13,315	13,060	8,945	11,960	8,190	19,440	8,190
	Other postgraduate	15,635	3,965	12,315	3,125	7,805	1,980	7,090	1,800	12,315	1,800
	Doctorate	2,970	1,185	2,705	1,080	1,265	505	1,220	485	2,705	485
	All	50,355	27,875	39,065	21,375	25,445	14,200	22,705	12,510	39,065	12,510
Total tier 2		83,340	60,695	60,710	43,250	27,355	18,925	19,480	13,555	27,355	18,925
Architecture, building and planning	Other undergraduate	1,730	1,550	1,245	1,115	910	815	425	380	910	815
	Foundation degree	225	225	180	175	110	110	40	40	110	110
	First degree	8,195	6,240	6,830	5,200	5,215	3,970	2,150	1,635	5,215	3,970
	Postgraduate	7,175	3,875	6,370	3,440	4,575	2,470	1,355	730	4,575	2,470
	Doctorate	380	155	340	140	65	25	45	20	65	25
	All	17,710	12,040	14,970	10,070	10,875	7,390	4,020	2,810	10,875	7,390
Computer science	Other undergraduate	2,810	2,550	1,490	1,350	515	465	450	405	515	465
	Foundation degree	580	575	280	275	155	155	150	150	155	155
	First degree	15,595	12,985	12,295	10,235	7,165	5,965	7,000	5,825	7,165	5,965
	Postgraduate	6,875	2,380	5,545	1,920	3,655	1,265	3,595	1,245	3,655	1,265
	Doctorate	910	375	830	340	325	135	320	130	325	135
	All	26,775	18,865	20,435	14,125	11,820	7,990	11,510	7,760	11,820	7,990
Mathematical sciences	Other undergraduate	725	630	470	410	85	75	60	55	85	75
	Foundation degree	-	-	-	-	-	-	-	-	-	-
	First degree	8,310	6,615	5,330	4,245	860	685	775	615	860	685
	Postgraduate	2,195	745	1,385	470	225	75	205	70	225	75
	Doctorate	665	320	560	270	105	50	100	50	105	50
	All	11,895	8,310	7,745	5,390	1,275	885	1,140	785	1,275	885
Physical sciences	Other undergraduate	1,635	1,505	980	905	150	135	105	95	150	135
	Foundation degree	315	310	155	150	20	20	10	10	20	20
	First degree	16,770	15,130	10,015	9,035	2,095	1,890	1,730	1,565	2,095	1,890
	Postgraduate	5,395	2,700	3,870	1,935	760	380	635	320	760	380
	Doctorate	2,845	1,830	2,540	1,635	365	235	325	210	365	235
	All	26,965	21,480	17,560	13,660	3,385	2,660	2,810	2,200	3,385	2,660
Total tier 3		611,285	457,180	492,215	364,320	24,175	16,380	14,210	9,090	14,210	9,090
Medicine and dentistry	Other undergraduate	305	275	145	125	85	75	-	-	-	-
	Foundation degree	-	-	-	-	-	-	-	-	-	-
	First degree	10,015	8,985	9,480	8,500	50	45	5	5	5	5
	Postgraduate	6,140	4,025	4,795	3,145	195	130	160	105	160	105
	Doctorate	2,260	1,615	2,000	1,430	65	45	60	40	60	40
	All	18,725	14,900	16,420	13,205	395	295	225	150	225	150
Subjects allied to medicine	Other undergraduate	16,690	16,200	14,485	14,060	265	255	85	85	85	85
	Foundation degree	1,905	1,870	1,555	1,525	100	100	25	25	25	25
	First degree	42,955	39,565	38,165	35,155	805	745	500	460	500	460
	Postgraduate	18,775	15,305	16,750	13,655	375	305	240	195	240	195
	Doctorate	1,340	870	1,220	795	75	50	60	40	60	40
	All	81,665	73,815	72,180	65,195	1,615	1,450	910	805	910	805
Biological sciences	Other undergraduate	4,660	4,335	2,715	2,525	245	230	150	140	150	140
	Foundation degree	1,205	1,180	545	535	20	20	15	15	15	15
	First degree	39,455	36,105	26,445	24,200	1,815	1,660	1,330	1,220	1,330	1,220
	Postgraduate	11,610	8,255	8,840	6,285	455	325	370	265	370	265
	Doctorate	3,395	2,405	3,035	2,150	105	75	80	60	80	60
	All	60,325	52,285	41,580	35,700	2,645	2,310	1,945	1,695	1,945	1,695
Veterinary science	Other undergraduate	30	20	30	20	-	-	-	-	-	-
	Foundation degree	-	-	-	-	-	-	-	-	-	-
	First degree	1,080	860	1,020	810	5	5	5	5	5	5
	Postgraduate	165	105	140	85	-	-	-	-	-	-
	Doctorate	65	50	60	45	-	-	-	-	-	-
	All	1,340	1,035	1,245	965	5	5	5	5	5	5

Table 10.7: continued

Agriculture and related subjects	Other undergraduate	815	735	500	455	25	20	20	15	20	15
	Foundation degree	870	870	390	390	30	30	20	20	20	20
	First degree	2,700	2,700	2,040	2,040	300	300	190	190	190	190
	Postgraduate	1,440	1,440	1,165	1,165	290	290	165	165	165	165
	Doctorate	200	200	175	175	15	15	10	10	10	10
	All	6,030	5,950	4,275	4,230	655	650	405	405	405	405
Social studies	Other undergraduate	5,225	4,830	3,515	3,255	95	85	35	35	35	35
	Foundation degree	1,895	1,895	1,390	1,390	25	25	5	5	5	5
	First degree	38,080	32,255	27,440	23,245	900	765	530	450	530	450
	Postgraduate	22,370	10,840	18,325	8,880	495	240	370	180	370	180
	Doctorate	1,930	850	1,730	760	55	25	55	25	55	25
	All	69,500	50,670	52,400	37,525	1,570	1,140	995	690	995	690
Law	Other undergraduate	2,060	1,825	1,095	970	55	45	30	25	30	25
	Foundation degree	115	115	115	115	-	-	-	-	-	-
	First degree	17,330	12,810	17,330	12,810	290	215	175	130	175	130
	Postgraduate	11,305	5,455	11,305	5,455	655	315	210	100	210	100
	Doctorate	430	160	430	160	15	5	10	5	10	5
	All	31,240	20,370	30,275	19,510	1,015	585	425	260	425	260
Business and administrative studies	Other undergraduate	8,475	6,400	5,780	4,365	545	415	360	275	360	275
	Foundation degree	2,515	2,295	1,555	1,415	290	265	255	230	255	230
	First degree	59,705	36,400	48,030	29,280	2,490	1,520	1,605	980	1,605	980
	Postgraduate	60,490	16,365	53,240	14,405	5,150	1,395	3,965	1,075	3,965	1,075
	Doctorate	1,150	430	1,045	390	40	15	35	15	35	15
	All	132,335	61,890	109,645	49,855	8,515	3,600	6,220	2,570	6,220	2,570
Mass communications and documentation	Other undergraduate	980	850	540	470	15	15	20	15	20	15
	Foundation degree	190	180	90	85	20	20	5	5	5	5
	First degree	10,585	8,795	8,470	7,040	320	265	205	170	205	170
	Postgraduate	6,175	2,455	5,345	2,125	160	65	120	50	120	50
	Doctorate	215	125	195	115	5	5	5	5	5	5
	All	18,145	12,405	14,645	9,835	520	365	355	240	355	240
Languages	Other undergraduate	3,710	1,865	1,660	835	110	55	85	40	85	40
	Foundation degree	10	10	-	-	-	-	-	-	-	-
	First degree	22,475	20,455	15,090	13,730	395	360	255	230	255	230
	Postgraduate	6,565	3,200	4,605	2,245	90	45	70	35	70	35
	Doctorate	1,215	685	1,040	585	15	5	10	5	10	5
	All	33,975	26,210	22,390	17,395	610	470	420	315	420	315
Historical and philosophical studies	Other undergraduate	1,780	1,675	1,045	985	95	90	65	60	65	60
	Foundation degree	255	250	155	155	10	10	10	10	10	10
	First degree	16,290	15,300	10,345	9,715	370	350	235	220	235	220
	Postgraduate	5,750	3,740	3,850	2,505	140	90	100	65	100	65
	Doctorate	1,310	790	1,030	620	15	10	5	5	5	5
	All	25,380	21,755	16,430	13,985	630	545	405	355	405	355
Creative arts and designs	Other undergraduate	4,085	3,385	2,075	1,720	160	135	35	30	35	30
	Foundation degree	1,960	1,715	790	690	75	65	15	10	15	10
	First degree	38,450	33,815	30,590	26,900	3,920	3,445	885	780	885	780
	Postgraduate	10,925	5,095	8,975	4,185	850	395	230	105	230	105
	Doctorate	645	395	590	360	35	20	30	20	30	20
	All	56,065	44,405	43,015	33,855	5,040	4,060	1,195	945	1,195	945
Education	Other undergraduate	8,900	8,660	8,105	7,885	115	110	70	70	70	70
	Foundation degree	3,375	3,365	2,225	2,215	10	10	5	5	5	5
	First degree	18,180	17,930	15,005	14,800	90	90	55	55	55	55
	Postgraduate	39,735	35,920	37,905	34,265	185	165	145	130	145	130
	Doctorate	850	520	785	480	10	5	10	5	10	5
	All	71,045	66,395	64,025	59,645	410	385	285	265	285	265
Combined	Other undergraduate	1,395	1,120	770	620	90	75	65	50	65	50
	Foundation degree	25	5	25	5	-	-	-	-	-	-
	First degree	4,005	3,875	2,800	2,710	455	440	355	340	355	340
	Postgraduate	100	95	100	95	5	5	-	-	-	-
	Doctorate	-	-	-	-	-	-	-	-	-	-
	All	5,525	5,095	3,690	3,425	550	515	420	395	420	395

Source: All data derived from HESA bespoke data request

10.18 Other undergraduate numbers refer to all those studying at undergraduate level except for first degree and foundation degrees

However, it is not only graduates from higher education that contribute to the supply of level 4+ engineers. Those with higher apprenticeships in an engineering-related framework are eligible to become employed in level 4+ engineering occupations. Thus, the numbers of those achieving higher apprenticeships (and other apprenticeships at level 4+) from the UK nations in 2014/15 are added to the two models of supply: a total of 800 apprenticeships (500 in England and 300 in Scotland). Despite this aspect of supply being very modest in scale, it should be noted that it has more than doubled since the previous year.

The contributions of the different graduate tiers, and from level 4+ apprenticeships, for each supply model are summarised in Table 10.8, which also provides the overall figures for the potential and historic supply approaches for those with level 4+ engineering-related skills. The total historic supply amounts to 41,325 whilst the potential supply is considerably higher at 81,430.

10.3.1 Supply calculation assumptions and sensitivity analysis

The model used to calculate these supply projections relies on a series of estimates and assumptions. The key assumptions are summarised here, together with brief consideration of the implications, and how sensitive the assumptions are to external effects:

The number of qualifiers used as the base figures combines all levels of study and both those who studied their degree full-time and part-time. Including part-time students in a calculation of potential entrants to the workforce is arguable, as some of these graduates would already have been working – some in an engineering role – while they studied, so they may already have been in the engineering workforce. It is not possible to differentiate the level at which they were working prior to study. Including those who studied part-time increases the starting total numbers of qualifiers.

Table 10.8: Calculation of supply of those with engineering-related skills at level 4+ (2014/15)

Supply source	Supply perspective	Criteria	Supply number
Tier 1: engineering and technology	Potential supply	All domiciled qualifiers in employment	39,065
	Historic actual supply	UK domiciled qualifiers employed in an engineering related role which is equivalent to graduate level (4+) skills and experience	12,510
Tier 2: architecture, building and planning; computer science; mathematical sciences; physical sciences	Potential supply	All domiciled qualifiers who are employed in engineering related role	27,355
	Historic actual supply	UK domiciled qualifiers employed in an engineering related role which is equivalent to graduate level (4+) skills and experience	18,925
Tier 3: medicine and dentistry; subjects allied to medicine; biological sciences; veterinary science; agriculture and related subjects; social studies; law; business and administrative studies; mass communications and documentation; languages; historical and philosophical studies; creative arts and designs; education; combined	Potential supply	All domiciled qualifiers who are employed in an engineering related role which is equivalent to graduate level (4+) skills and experience	14,210
	Historic actual supply	UK domiciled qualifiers employed in an engineering related role which is equivalent to graduate level (4+) skills and experience	9,090
Engineering-related apprenticeships		Apprenticeship achievements England and Scotland	800
Total supply at level 4	Potential supply	Tiers 1 + 2 + 3 + apprenticeships	81,430
	Historic actual supply	Tiers 1 + 2 + 3 + apprenticeships	41,325

All counts rounded to the nearest 5 per HESA data requirements.

The historic supply calculation works from a base of UK-domiciled qualifiers only, whereas the potential supply uses graduates who studied in the UK irrespective of domicile. The assumption is made that all these graduates could be eligible to study in the UK. This begs the question of whether this will continue to be the case as immigration policy evolves.

The number of graduates entering employment in the UK is calculated by multiplying either the number of UK qualifiers or the total qualifiers (of all domiciles) by the proportion of graduates that the DLHE survey recorded as employed. The factor used is the proportion (in each subject and level) for UK and EU domiciles combined. This is applied to graduates of all domiciles, which is an extrapolation, because the DLHE does not capture graduates from outside the EU. There could be some question as to the reliability of this extrapolation (of likelihood to work in the UK) to all nationalities if immigration policy changes or the UK becomes perceived as a less attractive place to work after study.

It would also be possible to apply the proportion of UK graduates entering employment to the UK qualifiers, but this would make only a small difference to the resulting figures.

The calculation of the proportion entering employment is also based on the destinations results for full-time and part-time study combined. The proportion of part-time study graduates in employment in the DLHE results is significantly higher. Applying this proportion to all qualifiers is likely to result in some inflation of the number calculated to enter employment.

The calculations for the numbers employed in an engineering occupation, and in an engineering occupation at level 4+, are both derived from the earlier columns, applying percentages based on DLHE results for UK- and EU-domiciles and those who studied full-time or part-time. Again, use of these ‘wide’ samples, and extrapolation to all domiciles – not just UK and EU – could have some impact on the numbers generated. It would be possible to use a more complex approach in future years, for example, to apply a DLHE result for UK domiciles to the UK numbers, and the wider UK + EU result to all domiciles combined. It is not certain without further detailed analysis whether such an approach would increase or decrease the net results, although the extent of impact is thought to be smaller than for the assumptions made for the earlier columns.

Overall, the assumptions made are believed to lead to an over-estimate for the extent of potential supply, and a very slight over-estimate for the historic supply. The impact of this in the context of a supply against demand projection is that any resulting shortfall is likely to have been under-estimated, at least to some extent.

10.3.2 Comparison with previous estimates of supply

The total potential supply of 81,430 is significantly higher than the comparable figure of 66,391 in the 2016 edition of this publication.

Comparing these projections reveals three areas of significant difference. The total number of qualifiers in the latest projections – for both UK and all domiciles in tiers 2 and 3 – is slightly lower than in the previous year. This reflects fluctuations in the total numbers of students, partly due to lower numbers studying part-time. However, this reduction is more than compensated for by larger calculated numbers entering employment in engineering occupations in this year's projections. This increase reflects two changes. The first is that there is some year-on-year change to the proportions of graduates of differing types who entered engineering occupations, as shown in Chapter 8. This could relate to the sector's continuing emergence from recession. Secondly, more than half of the difference is accounted for by postgraduates in tiers 2 and 3. In 2016, it was assumed that taught postgraduates in these subjects would not enter engineering occupations, so would not contribute to the supply numbers. We find no reason not to include graduates of this type, and have included their contribution this year. This results in an increase in the potential supply of over 8,000.

We note that the new potential supply projection of 81,430 is very close to that quoted two years ago, in the 2015 edition of this publication (82,000).[10.19]

10.4 Supply vs demand

Finally, Table 10.9 combines the projected demand figures and the potential supply of skills estimated in this chapter, for levels 3 and above.

It is accepted that the fulfilment of demand requirements (whether from replacement or expansion demands) does not have to be met entirely from new entrants to the workforce from education. There will be some additional inflows when people come back to the labour market after a period of inactivity, for example after unemployment, or as a result of inward migration. The scale of these inflows is currently hard to quantify, so the current model considers them to have a neutral impact on the projections.

This comparison of supply and demand therefore assumes that demand will need to be met from newly qualified people. The supply calculation is based on the total number who obtain qualifications, with multiplying factors to reflect known pathways into relevant working destinations. Therefore, it includes not only new entrants to the labour market from education, but also others who enter from either employment or inactivity via an educational programme. Those qualifying through an apprenticeship route are a prime example.

Notwithstanding these simplifications, this suggests that there will be shortfalls of engineers at levels 3 and above (Table 10.9). More specifically, the annual shortfall at level 3 is projected at just over 25,500, whilst the annual shortfall in engineering skills at level 4 or above could be around 20,000-60,000, depending on the assumptions made.

In the historic supply model, the numbers are based purely on UK-domiciled graduates and the historic supply is based on the most recent known destinations of these graduates. In other words, this is a model with no inward mobility into higher education. This would result in a shortfall of just under 60,000 per year at level 4+.

In reality, this is not the situation. It is known that some graduates from the EU and from other countries do enter engineering employment in the UK. The proportions who do so from EU countries and from within the UK are known, and the potential supply model applies that proportion to the entire number of international graduates rather than just the UK graduates. This projects an annual shortfall at level 4+ of just under 20,000 per year.

Table 10.9: Comparison of supply and demand projections for engineering skills, by level required (2014-2024) – UK

Level 4+		
	Total demand by 2024	1,012,230
	Annual demand	101,223
	Potential annual supply	81,430
	Historic annual supply	41,325
	Net shortfall based on potential supply	19,795
	Net shortfall based on historic supply	59,900
Level 3		
	Total demand by 2024	566,070
	Annual demand	56,607
	Current annual supply	30,925
	Net shortfall	25,680
Total level 3+		
	Total demand by 2024	1,578,300
	Annual demand	157,830
	Potential annual supply	112,355
	Historic annual supply	72,250
	Net shortfall based on potential supply	45,475
	Net shortfall based on historic supply	85,580

Source: Working Futures 2014-2024 and Engineering UK analysis.

Rounded supply and shortfall figures have been presented per HESA data requirements. Net shortfall has been calculated from unrounded supply figures.

10.19 EngineeringUK: *The state of engineering 2015*, December 2014. http://www.engineeringuk.com/Research/

These supply shortfall projections are somewhat lower than estimated in the 2016 edition of this publication. This is largely because higher supply figures have been projected this year, while the demand projection has not shifted greatly.

The potential supply calculation assumes that graduates of all nationalities who studied in the UK will be eligible to work in the UK, and are just as likely to want to work in engineering in the UK as UK and EU graduates. Should the eligibility for such migrants to work in the UK reduce, or the perceived attractiveness of working in the UK reduce, then the projected number would fall.

Put another way, the extent of supply at level 4+ based on the historic supply of UK graduates and level 4 apprentices is just over 41,000 per year, against a demand of just over 101,000. Assuming that international students continue to want to – and are eligible to – work in engineering occupations in the UK, then international graduates can add another c.40,000 to the potential supply. This would make a total of just over 81,000 – still short of the demand of over 101,000.

In this sense, the UK's exit from the EU presents significant vulnerability to future supply of engineers. With such dependency on international students, the flow of skills could change quite rapidly were there to be changes to the eligibility of prospective international students to enter HE in the UK, or work here afterwards, or to the perceived attractiveness to them of doing so. The very high proportion of international students of engineering and computing at postgraduate level is a small, but particularly vulnerable, aspect of engineering's current skills supply chain.

This demand model is based on our best available projections for the evolution of the economy and employment. It does not try to calculate the effect of the UK's withdrawal from the EU. This clearly has the scope to impact significantly on the demand side of the equation, through its impact on engineering activity and enterprises. The timescale for this type of impact could be more gradual than any impact upon the supply side.

The UK's position in relation to the EU places significant uncertainty on both sides of the supply/demand equation, but the potential extent of this uncertainty has yet to be modelled. However, whichever of the two versions of the current supply model is used, this analysis confirms that more needs to be done to expand the supply side of the skills equation for the engineering sector. In addition, we must ensure the continued contribution of graduates from outside the UK to the sector.

Along with protecting this flow of international talent, we must expand the UK supply pipeline and convert more of them into engineers by making the engineering sector/occupations more attractive.

Finally, we should consider initiatives that would improve retention within the sector and make it easier for working people to move into and between engineering sectors and occupations. We also need to reskill or upskill those people joining the engineering sector from other workforces.

Part 3 – Engineering in Employment
11 Focused employer activity

Key points

This chapter highlights some of the intelligence-gathering and policy activity by professional and employer organisations within the engineering sector. It also looks at how employers are responding by engaging with education, and provides examples of efforts to enhance UK productivity.

11.1 Demand for skills is rising fast

By Katy Pell, Campaigns Adviser, CBI

Businesses need increasing levels of skills among their employees – and the skill sets in demand tomorrow will be different from those in demand today. This opens up new opportunities for people to progress at work. However, the results from the *CBI/Pearson Education and Skills Survey 2016* show that firms expect to find it increasingly hard to secure people with the right levels and mix of skills to fill their growing number of skilled jobs in the future.[11.1] In the early stages of the UK's move to leave the European Union, it is of course not clear how access to migrant skills might change as a result. However, the priority for business is to tackle these issues and mismatches fully, so that the UK can push on to be a more productive, high-value economy and so that people can move up in their careers.

Businesses are facing substantial challenges recruiting the right skills for their current workforces and remain concerned that future recruitment will continue to be difficult. Our survey results from over 500 employers, who between them employ 3.2 million people, reveal a range of views and priorities, with a challenging future ahead:[11.2]

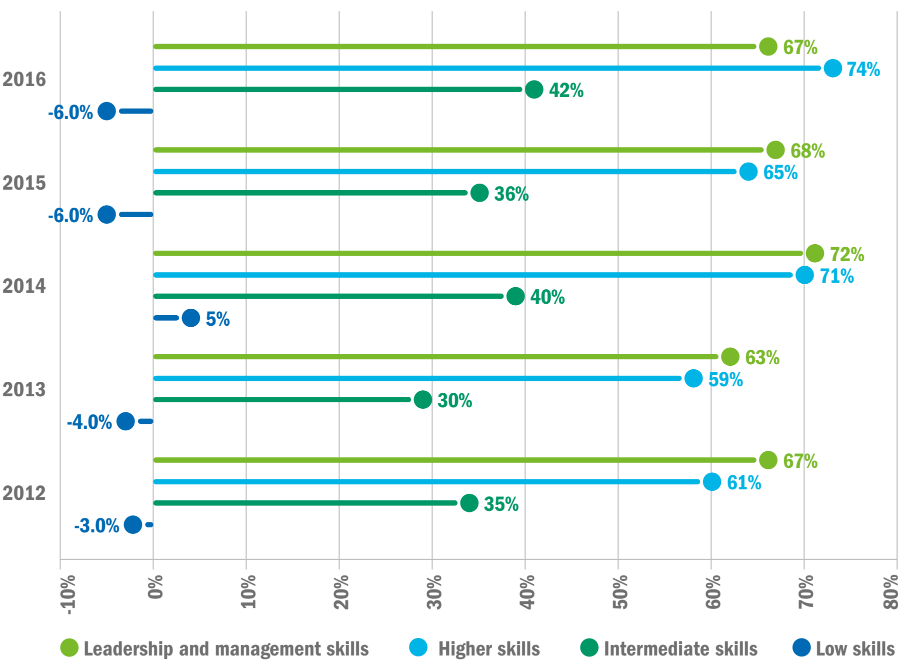
- Changing technologies and labour markets demand rising levels of skills…;
- … while those with the lowest skill levels will be increasingly at risk;
- More opportunities for those with skills seem set to open up across all sectors…;
- … but businesses fear growing shortages of skilled people;
- Worries over filling high-skilled posts apply across the UK…;
- … and affect firms of all sizes and in key sectors.

Changing technologies and labour markets demand rising levels of skills…

Businesses across the UK continue to need increasingly skilled employees. As technologies, products, services and markets evolve, the levels of skills needed to deliver them will also change, and are set to increase. It is vitally important to find ways to add to people's skills both to meet business needs and to enable individuals to progress into higher-skilled, better-paid work. The UK labour market has continually evolved and adapted through decades of economic change. Most recently, we have seen a 'new middle' emerge, where middle-skilled, middle-paying jobs require higher skills than they have previously.[11.3]

The UK's future relationship with the European Union will clearly impact on access to global talent and skills. However, before the referendum, businesses were clear about their domestic priorities and concerns – and these continue to hold true. Over the next three to five years, more than three quarters of businesses (77%) expect to increase the number of employees using higher-level skills in their jobs, while just 3% expect to reduce their number of higher-skilled employees (Figure 11.1). This gives a positive net balance of +74% of businesses expecting to grow their number of higher-skilled employees – an even larger positive balance than in earlier years. There will also be more opportunities for those with intermediate-level skills, with a balance of +42% of firms expecting to need to fill more jobs at this level.

Figure 11.1: Net demand for different skills levels over the next 3-5 years – (2012-2016 surveys)[11.4]



Source: CBI/Pearson

11.1 CBI: *The right combination – CBI/Pearson education and skills survey 2016*, July 2016. http://www.cbi.org.uk/cbi-prod/assets/File/pdf/cbi-education-and-skills-survey2016.pdf 11.2 CBI: *Ibid* 11.3 CBI: *A better off Britain: making growth work for everyone, 2014.* http://www.cbi.org.uk/better-off-britain/assets/download.pdf 11.4 These are percentages of firms reporting increased demand minus those reporting decreased demand

The results of our survey show the strength of the drive towards a higher-skilled, higher-value economy and the anticipated impact in terms of changing future skill mixes. However, that drive will not be possible if the right number of people with the right skills are not available. And individuals will be missing out on the opportunities for career and earnings progression that come with a move into more highly skilled work.

...while those with the lowest skill levels will be increasingly at risk

For those with only the lowest levels of skills, opportunities are likely to remain limited or even shrink. Over the next three to five years, more businesses (25%) expect to cut back on the number of low-skilled jobs than expect to grow the number (19%). This gives a net balance of 6% of respondents in 2016 expecting to decrease the number of low-skilled people they employ (Figure 11.1). As these results show, the best avenue to employment and income security lies through gaining and applying skills.

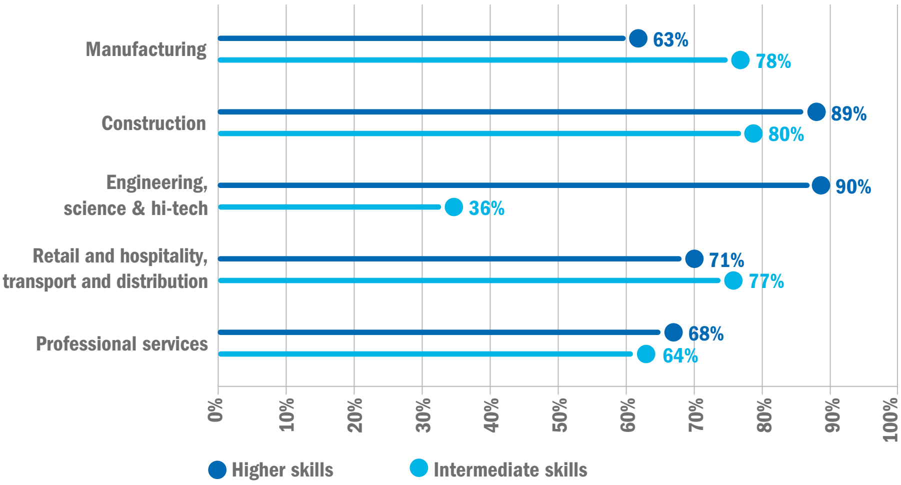
More opportunities for those with skills seem set to open up across all sectors...

Employer demand for more people with increased levels of skills in the next three to five years is expected to be strong across virtually all sectors of the economy (Figure 11.2).

In sectors as diverse as manufacturing, construction, and services such as retail and hospitality, and transport and distribution, positive balances of +50% and above of businesses anticipate needing more people with skills at intermediate levels in the years ahead. Demand for people with higher skills is expected to rise even more strongly. In construction, the balance of firms believing they will be looking to recruit more people with higher skills stands at +80%, and across businesses in engineering, science and hi-tech the balance climbs to +90%.

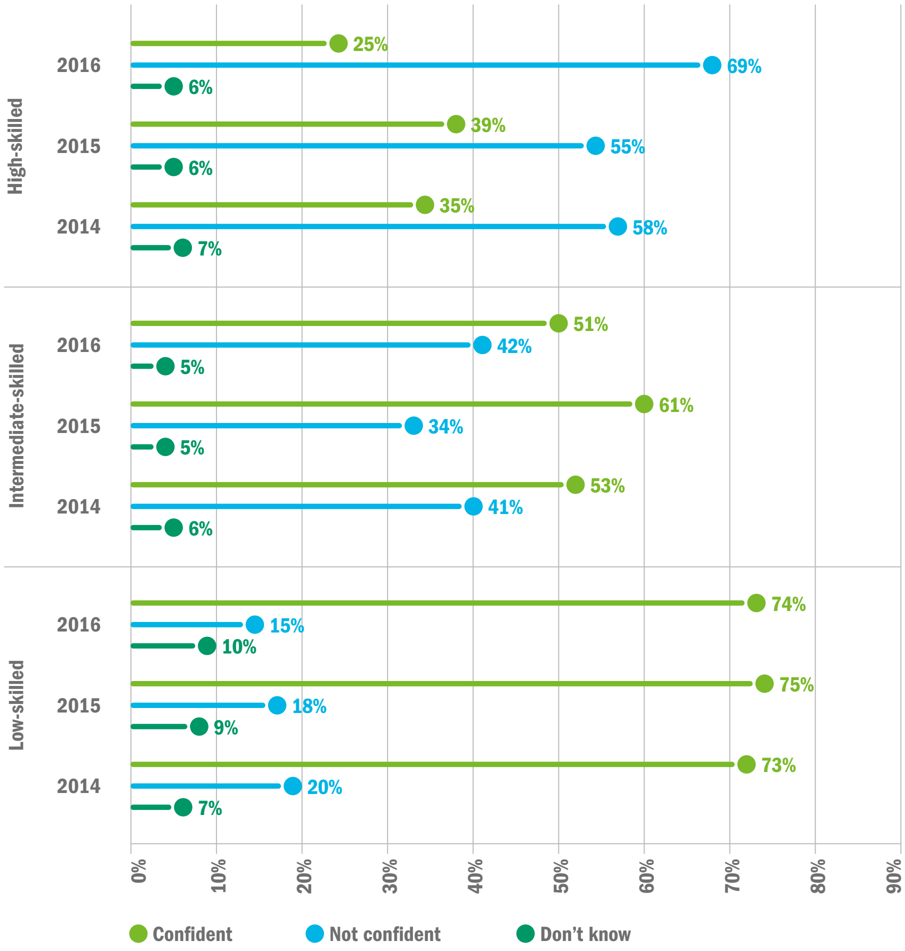
Achieving economic growth depends on the capacity to meet these skill needs in a new and changing trade climate. And if we are to achieve faster growth than in recent years, that capacity will need to be all the greater. This makes it essential both to keep developing the skills of those already in the workforce and to encourage young people to understand the opportunities open to them – so they can focus on developing the skills needed for a successful working life.

Figure 11.2: Net demand for higher and intermediate skills over next 3-5 years, by sector (2016)



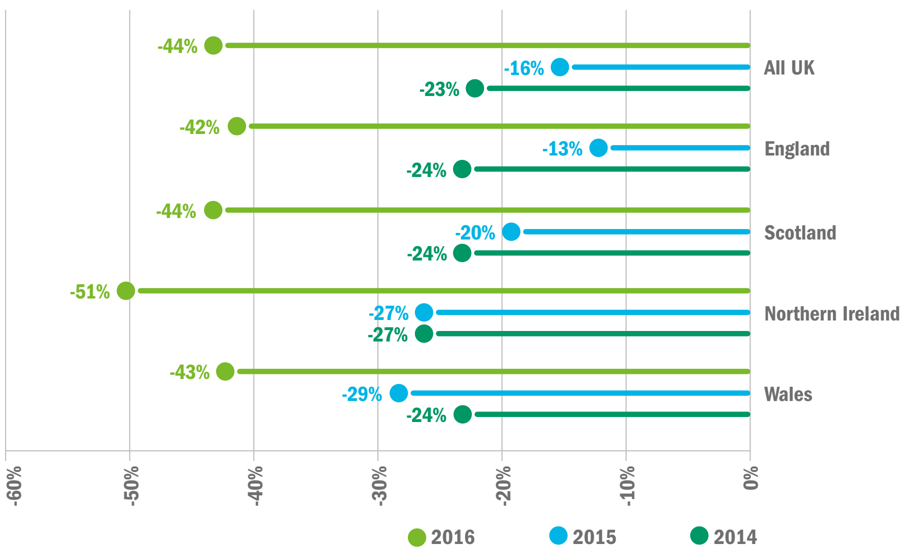
Source: CBI/Pearson

Figure 11.3: Employer confidence about accessing skilled employees in future, by skill level



Source: CBI/Pearson

Figure 11.4: Net confidence[11.5] about accessing high-skilled employees in future, by nation



Source: CBI/Pearson

...but businesses fear growing shortages of skilled people

Many firms are concerned that there will not be sufficient people available to fill their growing numbers of skilled roles in the future.

Most firms remain confident in their ability to fill their low-skilled roles, with a positive balance of +59% in 2016 (74% confident minus 15% not confident, Figure 11.3). But this year, the number of businesses confident about filling their intermediate-skilled jobs in the future has fallen and the number not confident has risen, which results in a net balance of 9% of businesses who are confident about the future supply of those with the intermediate skills they will need.

When it comes to filling high-skilled jobs in future, there are widespread concerns – and these have intensified. As we establish ourselves outside the European Union, we are likely to face an increase in labour market tightness. Not only will we have our existing UK skills shortages to address, but reduced access to migrant skills will also impact businesses. In 2015, over half of employers said they were not confident they would be able to recruit enough high-skilled employees (55%), while just over one third were confident (39%), giving a negative confidence balance of -16%. In 2016, there has been further erosion of confidence. The proportion of businesses *not* confident they will be able to meet their need for high-skilled people in the years ahead has climbed to more than two thirds (69%), with only a quarter (25%) confident. As a result, the net balance of firms confident they will be able to recruit to all their high-skill roles has reached a new low of -44%.

Worries over filling high-skilled posts apply across the UK...

Levels of confidence about being able to access sufficient high-skilled employees in future are increasingly negative across all parts of the UK (Figure 11.4). The biggest shortfall in confidence is among those businesses with employees in Northern Ireland (a heavily negative -51%), but negative balances of confidence about being able to fill high-skilled roles in the future stand at more than 40% in every nation of the UK.

11.5 Net balance of firms reporting 'confident' minus those reporting 'not confident'

...and affect firms of all sizes and in key sectors

SMEs, like larger firms, expect to need more people with higher skills over the next three to five years (with a positive balance of +75% of SMEs anticipating their demand will increase). Just under a third of SMEs (31%) are confident there will be enough of the right people available. But nearly two thirds of SMEs (63%) fear that in the coming years there will not be enough people to fill their high-skill jobs (giving a negative confidence balance of -32%). Among the largest businesses, with 5,000 or more employees, the negative balance of confidence about the future availability of high-skilled people climbs to -52%.

In manufacturing (Figure 11.5), there has been a further fall in net confidence about being able to recruit sufficient highly-skilled staff in future (from a balance of -47% last year to -58% in 2016). The decline in confidence is even greater in construction, reaching a negative balance of -74% this year. Even among professional services firms, where confidence about the future availability of high-skilled people was less of an issue up to 2015, there is now a clear negative balance in terms of confidence about the future availability of sufficient people to fill their high-skilled jobs (-11%).

These findings highlight the urgent need for more action to boost skills. They also show the growing opportunities open to those who develop the right skill sets. In the face of such low levels of employer confidence about the future availability of people with the right skills, there is a real risk that investment plans may be put on hold. Some operations could be transferred overseas to locations with a more reliable skills supply.

In particular, shortages of people skilled in science, technology, engineering and maths (STEM) have been a long-standing concern for businesses across the UK. This is summarised in the panel right, which is an extract from our 2016 report.[11.6]

Businesses showing students the value of STEM

The number of school leavers equipped with relevant STEM skills is lagging behind current and future business needs. The CBI has long advocated improving STEM participation in school, but there is often a struggle to prove to students the validity of STEM subjects in the working world.

Earlier this year, the CBI supported the release of *Tough choices*.[11.7] This was a report by the organisation Your Life, which looked into the reasons for students dropping STEM subjects at various stages of education. The 'STEM funnel' they use demonstrates that girls in particular drop STEM subjects at an alarmingly fast rate from primary school all the way through secondary school. In comparison, boys tend to fall off at a much slower rate, and only from their second or third year of secondary school.

One of the top methods of engaging students is through business involvement to give practical understanding of how STEM can be used in the wider world. Many CBI members are already deeply committed to engaging with schools with some impressive results. But more must be done if we want tackle the widening skills gap, particularly for those with an interest in STEM subjects.

To help businesses that want to engage with schools but are not sure how best to do so, the CBI has worked closely with the Royal Society on *Making education your business*.[11.8] This is a toolkit designed specifically to help those businesses that are currently under-engaged with schools to increase their involvement with practical advice, guidance and examples.

11.2 Manufacturers are tackling the skills challenge head on

By Verity O'Keefe, Senior Policy Adviser, EEF – the manufacturers' organisation

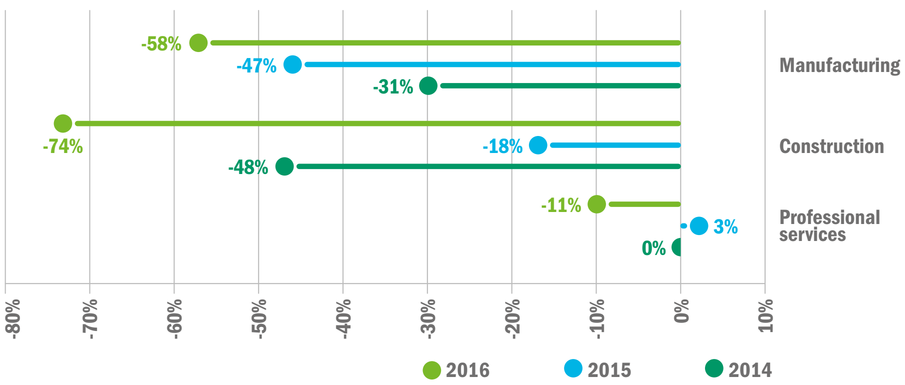
Annual editions of this report and other research have presented evidence that there is a major and potentially widening skills gap. In response to this, are employers investing sufficiently in training their current and future workforces? In 2016, EEF surveyed 239 manufacturing companies and found that manufacturers are continuing to invest in apprenticeships, are increasing their investment in training and are offering generous remuneration packages to attract and retain the right people with the right skills.[11.9]

11.2.1 Delivering gold-standard apprenticeships

There are few manufacturers that do not see the value of apprenticeships. Over two-thirds of companies we surveyed currently offer apprenticeships, and a further 14% are considering doing so. Only 5% have never offered them. Overall, plans to recruit apprentices are on the rise, as can be seen from Figure 11.6. Almost 80% of employers plan to recruit manufacturing and engineering apprentices in the next year, higher than the comparable figure recorded in 2012. Plans to recruit other apprentices were also higher.

Manufacturers are also generally recruiting younger apprentices, with 70% recruiting apprentices aged 16-18, and 29% recruiting 19- to 21-year-olds. They are also offering apprenticeships at all levels, with 73% offering Intermediate Apprenticeships, 64% Advanced Apprenticeships and 22% Higher Apprenticeships. The latter tend mostly to be offered by larger firms.

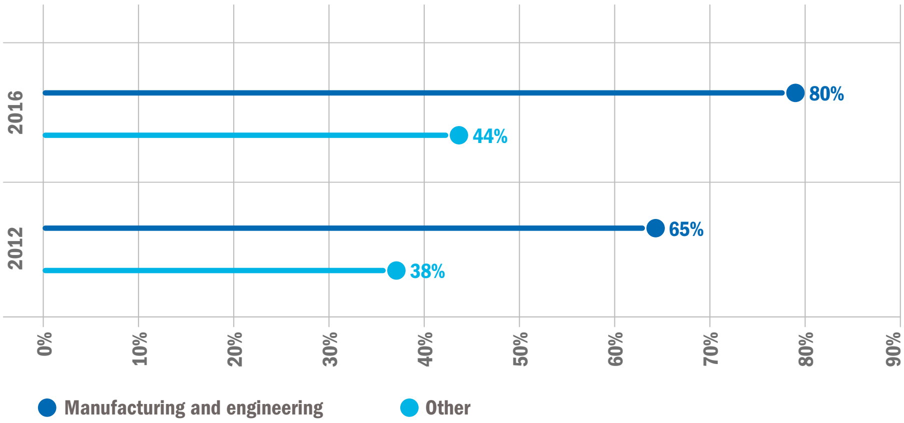
Figure 11.5: Net employer confidence in accessing high-skilled employees in the future, by sector



Source: CBI/Pearson

11.6 CBI: *The right combination – CBI/Pearson education and skills survey 2016*, July 2016. http://www.cbi.org.uk/cbi-prod/assets/File/pdf/cbi-education-and-skills-survey2016.pdf 11.7 AT Kearney and Your Life: *STEM skills gap. The real reasons A level students are steering clear of science and maths*, 2016. http://www.yourlife.org.uk/stem-skills-gap 11.8 Royal Society and CBI: *Making education your business*, May 2016. http://www.cbi.org.uk/cbi-prod/assets/File/Businesstoolkit.pdf 11.9 EEF – the manufacturers' organisation: *An up-skill battle – EEF skills report 2016*, 2016. https://www.eef.org.uk/resources-and-knowledge/research-and-intelligence/industry-reports/skills-report-2016

Figure 11.6: Proportion of companies reporting plans to recruit manufacturing and engineering apprentices, and other apprentices, in the next 12 months (2012 and 2016)



Source: EEF Skills Survey 2012 and EEF Skills Report 2016

11.2.2 Manufacturers continue to pay to train

When it comes to apprenticeships, manufacturers are more than willing to put their hands in their pockets: 71% of companies say that they are using a combination of employer and public funding to deliver their apprenticeship training, while just under one third (31%) are fully funding this training themselves.

Relying solely on employer funding is often a consequence of manufacturers bringing their training in-house, and can result in a loss of public funding. Others may pay for training entirely themselves due to the perceived or experienced complexities involved in engaging with the funding system. The way apprenticeships are funded is, however, radically changing with the introduction of the new Apprenticeships Levy.

The importance placed on training has led to almost two-thirds of companies in our survey (63%) expecting their company to increase its training spend in the next 3 years, with around a third (32%) saying it will remain the same and just 4% expecting it to decrease. Moreover, manufacturers are not just focusing on a single delivery model but, instead, say they are using a variety of ways to deliver their training.

11.2.3 Competitive salaries help to attract and retain top talent

Pay can often be an indicator of both skill level and shortage of skill supply. The vast majority of manufacturers (82%) believe they are offering competitive salaries to attract and retain highly-skilled employees.

EEF's own pay benchmarking data has found a steady increase in pay levels for key engineering positions in recent years. In particular, engineers with higher skills and greater experience have seen their pay increase more significantly than their junior counterparts. Even when we have seen a dip in overall pay settlements for the industry, manufacturers have continued to report higher than average rates for what they consider to be 'skills hotspots'.

11.2.4 Career progression and training opportunities give employers the edge

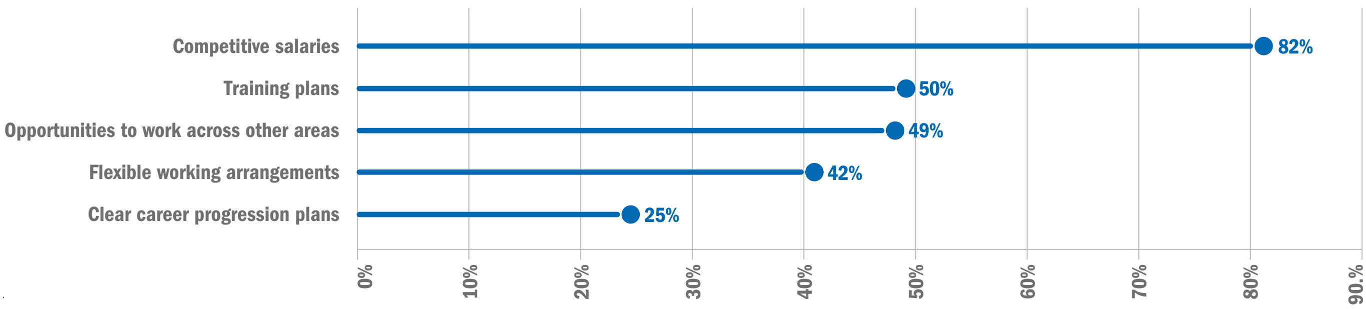
Once a new member of staff has been recruited, having the opportunity to move around the organisation and progress is important. Half of companies say that they offer training plans as a retention tool and 49% are offering opportunities to work across other areas of the business (Figure 11.7). This is mutually beneficial: for the employer, an employee who spends time on the factory floor and then in the sales and marketing team is more likely to hold a wider skill-set that stands a better chance of meeting more of the range of business priorities.

While training plans are used widely, only a quarter (25%) of manufacturers provide clear progression plans for their employees. Marrying up training and working across the business with clear career progression planning could create a better formula for retention, yet too many employers are falling short of this aspiration.

11.2.5 Encouraging agile ways of working is becoming the norm

Reflecting greater employee demand for flexibility, 42% of manufacturers say that they are using flexible working arrangements to attract and retain employees. However, the right of an employee to request flexible working and the company actually agreeing to a flexible working pattern are two different things. Manufacturers we surveyed were keen to demonstrate that offering flexible working usually meant reaching an agreement with an employee of a way of working that was mutually beneficial. That flexibility can be used as a recruitment and retention tool, and it is noticeable that more employers are making their willingness to be flexible more public as part of their attraction strategy for potential employees.

Figure 11.7: Proportion of companies offering different options to attract and retain skilled employees



Source: EEF

11.2.6 Retaining older workers with specialist skills

It has been demonstrated elsewhere in this report that the average age of employees in the engineering sector is rising slightly, and our survey confirms that manufacturing has an ageing workforce. Two in five manufacturers report that over 40% of their workforce is aged over 50 (Figure 11.8). The abolition of the default retirement age has created further challenges in this area but also opportunities, such as an opportunity to retain specialist skills.

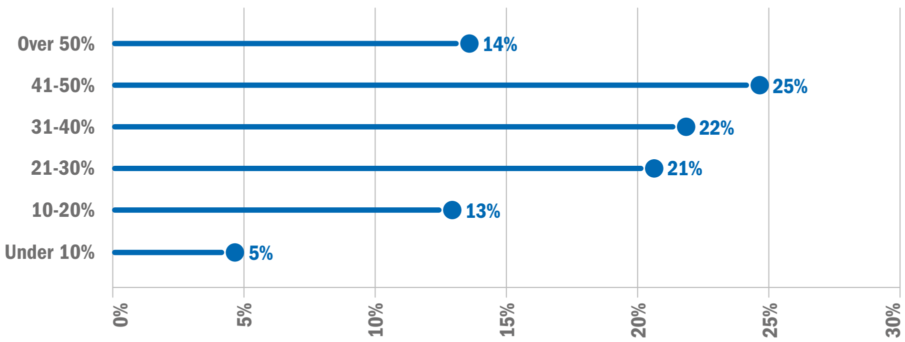
The retention of older workers with specialist skills offers one of the potential solutions to the skills gap. One third of employers responding to the survey reported that they think they will be able to retain specialist skills as a result of the abolition of the default statutory retirement age. In the cases where employers are not confident that they will have sufficient entry-level talent coming into the business, or the potential to progress current employees through the business, then retaining specialist skills through the continuing employment of older workers constitutes a useful solution – employers will try to keep hold of key skills however they can.

11.2.7 Broadening recruitment internationally

Many manufacturers operate globally. Their ambitions to supply new markets and to make use of a variety of effective supply chains can mean expanding their activities all over the world. Recruiting employees from within and outside Europe, as well as transferring and posting employees all over the globe, is often a necessary response to meet the skills needs that are required to fulfil these international ambitions.

The 2012 EEF skills survey found that 25% of employers were specifically recruiting from other European countries to access certain skillsets, and that 11% were recruiting from countries outside the European Economic Area (EEA).[11.10] In 2016, the proportion of manufacturers that have specifically recruited EEA employees from outside the EEA has fallen to 9%. This is likely to reflect the increasing cost and complexity of recruiting from outside Europe, as immigration policies and regulations have been refined. Previous EEF research has found that employers find the process of recruiting non-EEA employees both time-consuming and complex. They face difficulties and costs in securing sponsorship licences and the right type of visas. This is likely to escalate further, with employers facing rising costs in 2017 as regulations evolve. The minimum salary threshold for recruiting highly skilled migrants, and bringing employees over to a UK branch of a business, is set to increase significantly. In addition, employers will be faced with a new Immigration Skills Charge, to be paid per employee, per year. Whether current policy discussion around reporting of non-UK staff will lead to other obligations is yet to be seen.

Figure 11.8: Proportion of employers' workforces comprising employees aged 50 and over



Source: EEF

11.2.8 Solving the problem

With employers across manufacturing taking such an array of actions to assure effective recruitment and retention of skills, it would be easy to assume that the sector is some way to closing the skills gap. Unfortunately, none of activities discussed are easy within a tight economy and employers report a number of barriers, including:

- **Difficulties in recruiting more apprentices:** challenges in finding the right quality candidates, in obtaining relevant, local provision, and the sheer monetary cost – all of which will only increase further with the introduction of the Apprenticeships Levy;
- **Managing employee demands and expectations:** manufacturers often cite a mismatch of salary expectations between what the business can offer and what a prospective candidate expects. Employers also state that, while they may offer career progression and training plans, one of the main barriers to implementing these is in fact employee demand;
- **Retaining older workers can be challenging:** Some manufacturers report a reduction in productivity levels amongst the older workers that they retain, particularly following the abolition of the default retirement age. Others say it can make succession planning difficult;
- **Global recruitment is only going to become more difficult:** As well as difficulties in recruiting non-EEA employees, as cited above, employers are already raising concerns about their ability to attract and retain EU nationals after the UK referendum result. Manufacturers currently rely heavily on EU workers, so any restrictions imposed on their ability to recruit them in future, or shifts in perceptions about the desirability of the UK as a place to work, will make the skills challenge even harder.

11.10 EEF: Skills for growth, 2012.

Back to Contents

11.3 Recognising professional excellence in engineering

By Jon Prichard, CEO, Engineering Council

11.3.1 Regulation of the engineering profession

There are many forms of regulation in the UK, ranging from statutory regulation that imposes legally-enforceable restrictions and requirements, through to self-regulation that is based on voluntary codes and practices. Statutory regulation should only exist where there is a legitimate public interest. The UK democratic system generally prefers professions to be self-regulating. In the main, there is no statutory requirement for engineers or technicians to be registered, although there are some isolated areas of practice where public registers are maintained. These include supervision for reservoir safety, aircraft repair and maintenance, and nuclear process safety.

The government does, however, recognise the value of professional self-regulation. Accordingly, it has awarded Royal Charters over the years to appropriate professional bodies to deliver this public benefit, thereby encouraging the attainment of professional standards and adherence to codes of conduct. As a result, society can have confidence that professionally-registered engineers and technicians have made a commitment to maintain their competence and to adhere to a code of conduct.

11.3.2 Professional registration

The Engineering Council is the chartered body where the engineering institutions meet to set the collectively agreed standards for the registration of competent engineers and technicians on behalf of society. It maintains the national register of all those who have been assessed as attaining or exceeding these standards, and keeps the standards under periodic review to ensure that they continue to meet the needs of both employers and the public at large.

The resulting UK Standard for Professional Competence (UK-SPEC)[11.11] is published by the Engineering Council. It was most recently reviewed in 2013 and the third edition was published in January 2014. The engineering institutions have collectively agreed the procedures that they must each follow to ensure that a consistent registration standard is maintained. They then subject themselves to periodic review by their peers through a licensing process that is managed by the Engineering Council.

The actual process of assessing individuals for admission to the national register is therefore undertaken independently by each licensed professional engineering institution. There are currently 35 of these.[11.12] The Engineering Council manages the programme of periodic peer review to ensure ongoing compliance, and works with international partners to make sure that registered engineers and technicians satisfy internationally-agreed standards of education and practice.

The categories of registration set out in UK-SPEC are:

- Engineering Technician (EngTech), which requires evidence of competence, including academic knowledge and understanding, at or above level 3;[11.13]
- Incorporated Engineer (IEng), which requires competence underpinned by academic knowledge and understanding at or above level 6 of the National Qualifications Framework (for example, an accredited bachelor's degree or equivalent;
- Chartered Engineer (CEng), which requires competence underpinned by academic knowledge and understanding at or above level 7 of the National Qualifications Framework (for example, an accredited integrated master's (MEng) degree or equivalent).

The Engineering Council also operates the register for those that meet the ICT Technician (ICTTech) standard,[11.14] which is broadly equivalent to that of Engineering Technician.

Candidates for all four registers must, in addition to demonstrating their competence to practise in accordance with the relevant standard, also demonstrate that they are committed to maintaining their competence and to acting in a professional and socially-responsible manner.

11.11 Engineering Council: *UK-SPEC* (web page), 2015. http://www.engc.org.uk/ukspec 11.12 Engineering Council: *Our Partners* (web page), 2015. http://www.engc.org.uk/institutions 11.13 The equivalent levels on the Scottish Credit and Curriculum Framework are 6, 9/10 and 11 respectively. 11.14 Engineering Council: *Information and Communications Technology Technician* (web page), 2015. http://www.engc.org.uk/icttech

Back to Contents

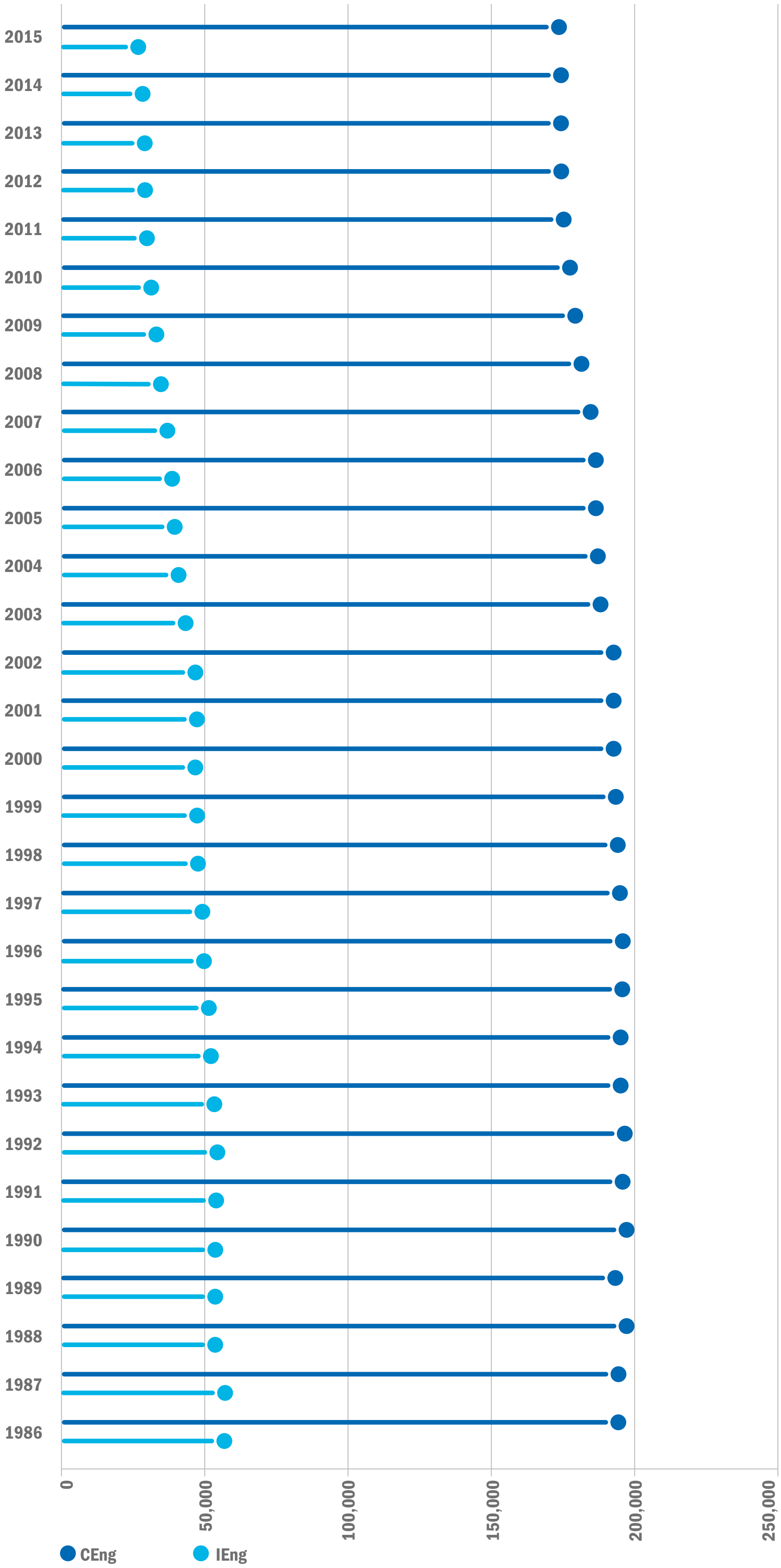
11.3.3 The number of professionally-registered engineers

Over 175,000 individuals are currently registered with the Engineering Council as Chartered Engineers and just under 30,000 as Incorporated Engineers. The overall number of professionally-registered engineers has declined since its peak in the 1980s (Figure 11.9). However, over the last couple of years there has been a levelling out.

When looking at the age profile of registrants, and making assumptions about age of retirement, the downward trend in the number of professionally-registered engineers appears to reflect the demographics of the national population, and is therefore not a huge surprise (Figure 11.10).

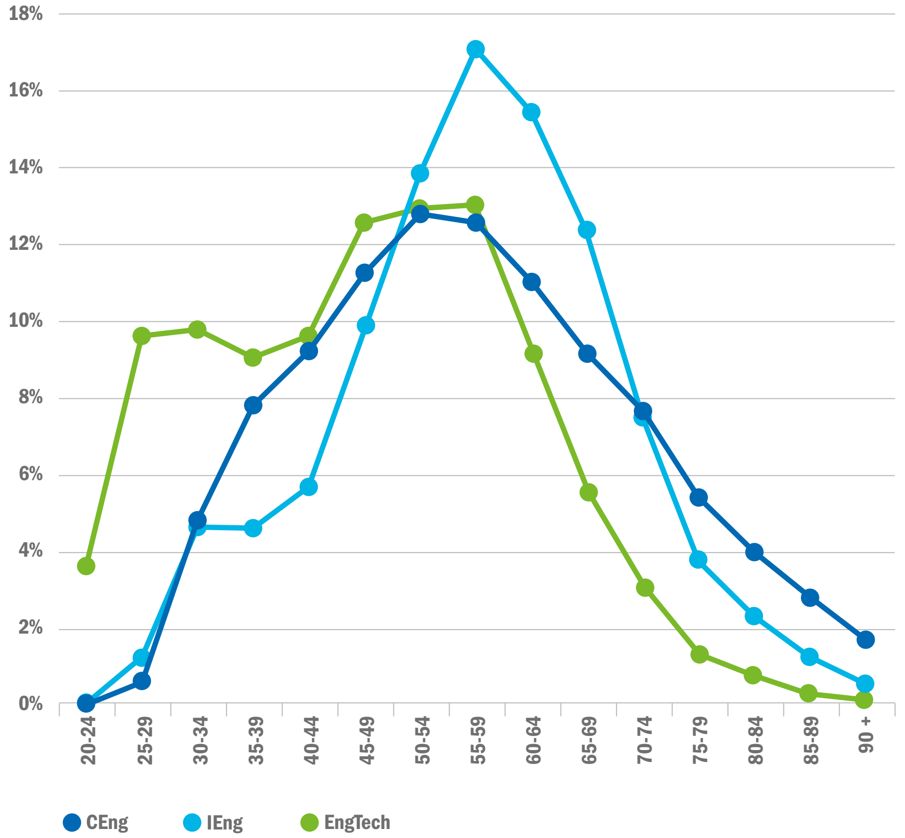
However, the trend for new registrations has shown a gradual increase over the last few years (Figure 11.11). This indicates that more graduates than a decade ago are electing to join professional bodies and are being encouraged to become professionally-registered.

Figure 11.9: Total number of registered Incoporated Engineers and Chartered Engineers (1986-2015)



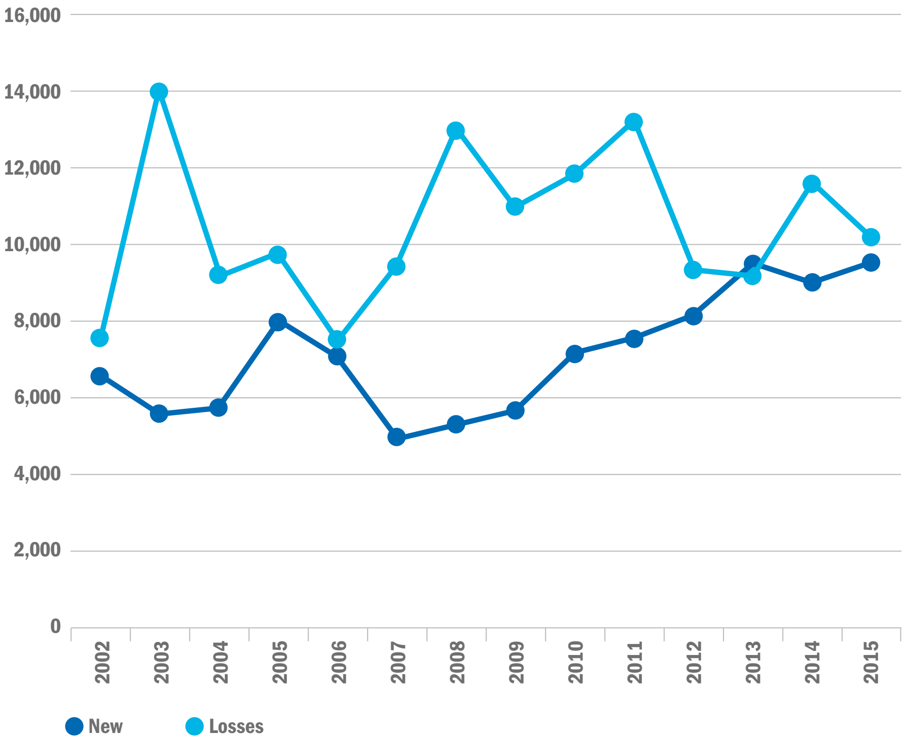
Source: Engineering Council Annual Registration Statistics 2015

Figure 11.10: Age distribution of Engineering Technicians, Incorporated Engineers and Chartered Engineers (2015)



Source: Engineering Council Annual Registration Statistics 2015

Figure 11.11: New registrants versus losses from the register (2002-2015)



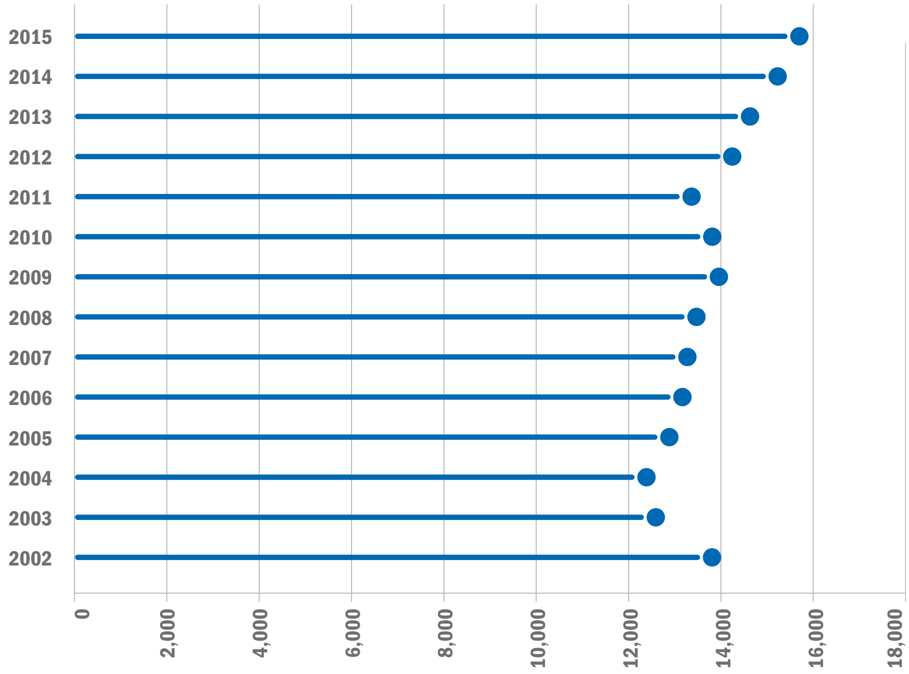
Source: Engineering Council Annual Registration Statistics 2015

The number of professionally-registered Engineering Technicians (Figure 11.12) is significantly below the number of potential technicians in the UK. Major initiatives are currently underway to address this.

11.3.4 Professionally-registered female engineers and technicians

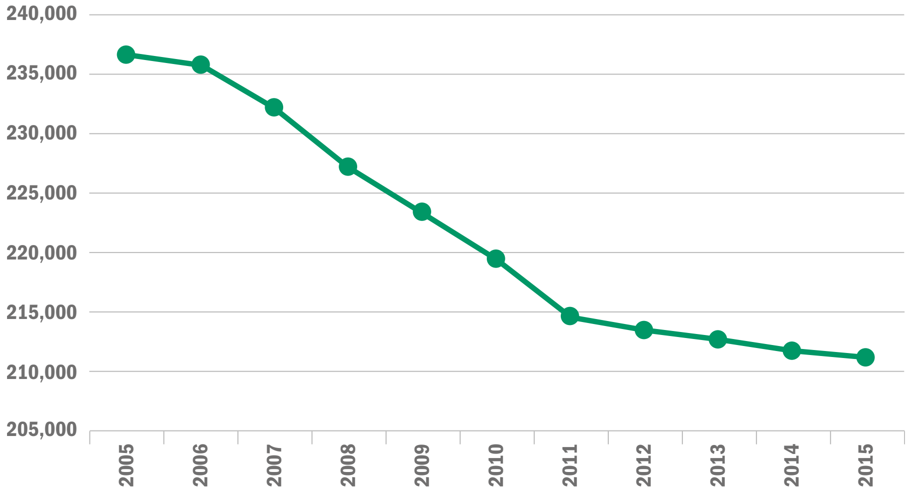
Although females currently only represent 4.9% of those on the national register, their total numbers continue to rise steadily, albeit from a low base. It is worth noting that this increase compares well when set against a backdrop of a decreasing male population over the same period (Figures 11.13 and 11.14).

Figure 11.12: Total number of Engineering Technicians (2002-2015)



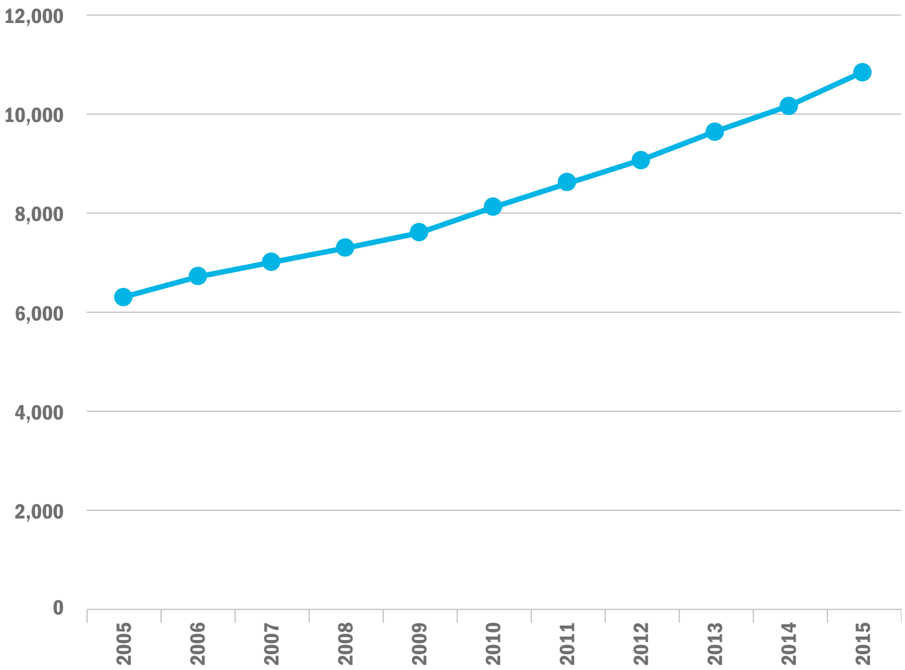
Source: Engineering Council Annual Registration Statistics 2015

Figure 11.13: Total number of male registrants (2005-2015)



Source: Engineering Council Annual Registration Statistics 2015

Figure 11.14: Total number of female registrants (2005-2015)



Source: Engineering Council Annual Registration Statistics 2015

11.4 Employer engagement in education

Ultimately, engineering employers will make the most significant contribution to their own success – and to UK productivity – by recruiting skilled employees. One measure of how they are engaging with young people in education comes from the UK Commission for Employment & Skills (UKCES) survey, which asks employer respondents about their provision of work placements and 'work inspiration' activities.[11.15] This data is also being used by the Careers & Enterprise Company (CEC) as part of its measures to understand geographic areas of careers and enterprise need. CEC is mapping hot and cold spots of activity as part of its role to support engagement of schools and employers.

The most recently published results are from the 2014 survey, as the 2016 survey was underway at the time of writing. Across England, 17% of employers claimed to have offered some kind of work inspiration activity in the previous 12 months. Analysing the data by Local Enterprise Partnership (LEP) and local authority shows that this extent varied considerably with geography, from 11% of employers in the Tees Valley to 25% in Cheshire and Warrington. Young people in education were most likely to be offered work inspiration activities around Oxfordshire and Buckinghamshire, Liverpool City Region, Cheshire and Warrington, and Dorset. Interestingly, several of these areas had been supported by active Education Business Partnerships, before that form of structural support ceased. In contrast, the Heart of the South West LEP and the Tees Valley reported the lowest proportion of employers engaged in work inspiration activities.[11.16]

Of the 17% of employers who reported that they had conducted work inspiration activity, just over half had been with schools. This represented just over 9% of English employers. There was also evidence that employers in the manufacturing (13%) and construction (6%) sectors were less likely to offer work inspiration than those in financial services (18%) or business services (19%).

There is some divergence in reporting of the extent to which employers are offering work experience. However, this varies with location and is likely to have shifted somewhat since the statutory requirement for work experience at school was removed. Some areas have continued to prioritise it, while others have focused their support in other ways, such as much more targeted support for disadvantaged children. The 2014 UKCES survey suggested that 38% of employers in England had offered a work experience placement in the 12 months prior to the 2014 survey. This varied from 29% in the Humber area to approaching half in London and Cheshire and Warrington. Overall, young people in the south of England were slightly more likely to be offered work experience than their counterparts living in northern England. The trend between sectors was broadly similar for provision of work experience placements.

This data seems to conflict somewhat with results from the *2016 CBI/Pearson Education and Skills Survey*, which reported that as many as 80% of employers have some link with schools or colleges. It also reported that over three quarters of these employers provide work experience for pupils or students, and a similar proportion engage through staff by giving careers talks or other input.[11.17] The much higher figures in the CBI survey could reflect differences in the profile of employers responding to these two surveys, as well as differing interpretations of the measure being probed. Unsurprisingly, larger employers tend to be more engaged than smaller ones.

It seems likely that the current policy emphasis on increasing the level and extent of engagement between employers and schools will result in more consistent measures being available in future years, as well as greater insights into the impact of those interactions. One insight is given in Chapter 4, where is it shown that the number of external careers talks attended by young people in certain secondary school years correlated with higher earnings ten years later.[11.18]

11.15 UKCES: *Geographical variation in access to work placements and work inspiration: data from the Employer Perspectives Survey 2014*, February 2015. https://www.gov.uk/government/publications/Employer-Perspectives-Survey-2014-England-and-local-data **11.16** UKCES: *Employer Perspectives Survey 2014: England and local data*, 2015. https://www.gov.uk/government/publications/Employer-Perspectives-Survey-2014-England-and-local-data **11.17** CBI: *The Right Combination – CBI/Pearson Education and Skills Survey 2016*, July 2016. http://www.cbi.org.uk/cbi-prod/assets/File/pdf/cbi-education-and-skills-survey2016.pdf **11.18** E. Kashefpakdel and C. Percy: *Career education that works: an economic analysis using the British Cohort Study*, (Journal of Education and Work), 2016; http://dx.doi.org/10.1080/13639080.2016.1177636

11.5 Employer cameos

The following are brief perspectives provided by organisations that are members of Engineering UK's Business and Industry Panel. They were invited to contribute a short response to describe how they view the key factors in helping their organisation drive its productivity.

AIRBUS

Airbus in the UK designs and assembles wings for the entire family of Airbus commercial airliners, and has invested more than £2 billion in new technology and facilities to boost productivity. The Factory of the Future project in Broughton, North Wales will introduce increased automation in the wing assembly process for A320 family aircraft. The £48 million "Step Change" project is at the heart of a production ramp-up for the world's most popular short-to-medium range aircraft which will ultimately see 60 aircraft per month being built by 2020. The Filton site, near Bristol, designs and develops aircraft systems and the wings and underpins the manufacturing work undertaken at Broughton.

ch2m

As a company delivering some of the UK's largest infrastructure programmes, CH2M acknowledges that increasing productivity is essential for driving best value as well as on-time and on-budget delivery. In order to deliver this value CH2M adheres to the principles of 'lean' project delivery, to reduce timelines, minimise waste and maximise efficiency that we can pass onto our clients. We deliver this through collaboration between clients, engineers and construction teams that take a whole life view of a project from design to close out. When combined, these incremental steps can produce significant cost savings and in turn massively increase productivity.

GE

Digital is the key to driving positive outcomes in productivity and efficiencies within an organisation and for industry as a whole. The merging of the digital world with the world of machines – what we call the industrial internet – holds the potential to bring about profound transformation to global industry, creating efficiencies which translate into real growth. At GE, we've seen Industrial Internet solutions improve our customers' efficiency by an average of 20% and in the first half of 2016 GE has seen some $250 million productivity savings in our own operations by creating a 'digital thread' across our businesses.

ATKINS

There's no silver bullet to address productivity – it's a complex challenge with a multi-faceted solution. People are at the core and providing them with the skills and development they need to do their jobs efficiently and effectively are vital. It then comes down to how we deliver projects. Disruptive innovation can create new markets and opportunities, taking a whole-life approach enables a focus on outcomes, cross-sector thinking allows the best ideas to be shared and adapted, and effective risk management provides certainty in an uncertain environment. These, combined with vastly improving data, help people make the right decisions at the right time.

DOOSAN

Doosan Babcock has undertaken a business transformation programme to support a sharper focus on the needs of our customers and allow us to respond to the challenges of a changing marketplace. We have set out a new vision for the company, focused on sustainability for our business and our customers, and underpinned by the restructuring of our organisation and the re-engineering of core business processes such as procurement and resource allocation.

Our focus is on ensuring we operate a customer-centric business model that provides value to our customers through greater operational efficiency and reduced waste. This has included the implementation of a single project delivery structure for improved pooling of engineering and technical expertise, skills and resources.

hs2 engine for growth

Transport infrastructure is a key driver of productivity. Good transport networks improve connectivity, bringing businesses and people closer together to facilitate access to markets, suppliers and skills, and enabling trade and sharing of knowledge. This increases productivity. In addition, failing to invest in new rail capacity risks constraining productivity through negative effects such as congestion and overcrowding. HS2 is the biggest transport infrastructure investment in the UK for a generation. It will add capacity by providing a network of new high speed lines across Britain and deliver significant improvements in connectivity on key routes. At HS2 Ltd we're committed to achieving the productivity potential of the HS2 project, and to help boost economic growth.

Jaguar Land Rover is the UK's largest automotive manufacturer. To boost our productivity and deliver our ambitious plans for growth, we have invested heavily in skills, facilities and innovation, including over a £100 million per year on training at the Jaguar Land Rover Academy. A quarter of our workforce is in further or higher education and skills training. We also work with young people from primary school to university age to deliver a range of engaging STEM challenges and activities; including via our 'Inspiring Tomorrow's Engineers' programme to promote engineering and manufacturing careers to young people. Our investment in cutting-edge technologies has exceeded £12 billion in the last five years and will invest a further £3 billion in this financial year alone.

Our organisation is primarily involved in the development and optimisation of infrastructure. For many years this was driven by a requirement to achieve highly-specified project outputs. More recently there has been a shift towards clearly communicated outcome requirements. This allows the supply-chain to collaborate more freely, driving much greater levels of innovation and productivity. Effort can be prioritised to the most carbon-favourable and cost effective way to achieve the outcome required thereby maximising benefit against investment made. Our internal productivity is driven by high levels of staff engagement, a well-organised functional structure and early adoption of the latest technology.

Rolls-Royce designs, develops, manufactures and services integrated power systems for use in mission-critical applications in the air, on land and at sea. Three factors drive our productivity: first and most critical is our people. We work in a high-end engineering environment that demands high skills and capability – and is why we are focused on inspiring and shaping a diverse pipeline of talent in STEM through engaging our people. Secondly, there are our processes that need to be lean, simple and agile. Thirdly, our working environment and tools to do the job so that we have efficiently designed factories using advanced technology.

With over 30 years' experience in successfully matching job-seekers with hiring employers across the engineering industry, we've grown to believe the most impactful factor in driving productivity is hiring and retaining employees who are self-motivated, display high levels of capability, and are the right cultural fit for the organisation.

Within our own business, we source the best recruiters to work for us and keep our employees motivated by offering regular training and development opportunities, a clear progression path and reward and recognition for their hard work. We're proud to help our clients find the right talent to take their business forward.

Unprecedented growth has placed an ever-greater importance on productivity at Network Rail. Every year our infrastructure helps move 1.7 billion people and 86 million tonnes of freight across the country quickly, safely and efficiently. With demand at its highest since the 1920s, engineers must work quicker and safer than ever to carry out essential maintenance and upgrades. Handheld devices modernise and speed up day-to-day operations while custom apps streamline tasks. The infrastructure is changing too. As well as building new rail links and stations to cope with more passengers, we must modernise to unlock capacity on the railway allowing trains to run closer together, safely and more reliably.

Manufacturers have a key role in solving the UK's so-called 'productivity puzzle'. According to a Siemens consultation among the manufacturing community, they are clear on the priorities to improve matters. Siemens believes more must be done in critical areas such as developing workforces with industrial digital skills for future needs, together with a renewed emphasis on STEM education. Sustained Government investment in critical infrastructure – road, rail, ports and communication – would enable them to reap the productivity benefits of new technologies such as digitalisation and automation. Companies should be encouraged to create a spirit of innovation in product development and advanced high value manufacturing so ingenious ideas can be turned into commercial reality.

Continued productivity growth for our group is achieved by the application of business and industry insight. With the engineering industry experiencing its fiercest competition for talent to date, the need to be one-step-ahead to secure the best solution delivered by the best talent is critical. Business intelligence is presented via real-time reporting dashboards which provide visibility of performance gaps and, therefore, drive focused improvement. Similarly, this insight is used to reward and emulate service excellence across the group. Consistently, we use information as the foundation to recognise, nurture and reward, ensuring we retain a well-motivated and productive workforce at the core of our business and that is aligned to our clients.

Annex

The annex is a standalone, web-based document. By making the annex a separate document, we are able to include more detailed information and will also be able to update it if required during the course of the year.

The annex can be accessed at:

http://www.engineeringuk.com/media/1350/EngineeringUK-Report-2017-Annex.pdf

EngineeringUK

EngineeringUK is an independent organisation that promotes the vital contribution of engineers, engineering and technology in our society. We partner with business and industry, government and the wider science and engineering community to produce evidence on the state of engineering, inspire young people to choose a career in engineering, and match employers' demand for skills. EngineeringUK works across the engineering community to deliver two programmes: The Big Bang and Tomorrow's Engineers.

For more information about EngineeringUK, please visit:

www.EngineeringUK.com

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