Department
for Business
Innovation & Skills

Professor John Perkins'
Review of Engineering Skills






November 2013

Dear Secretary of State

Everyone recognises that our rapidly changing economy is placing ever-greater demands on the skills of the workforce. If we are to compete in the global race, we need to equip our people with the skills to adapt, innovate and flourish. Given the rapid technological change we are facing, science, technology, engineering and maths (STEM) skills are especially vital, so I was delighted to accept your request to review the provision of engineering skills in our economy.

Of course, concern about the provision of engineers is nothing new. Over the past 150 years, public and business concerns prompted periodic investigations into the nature, scale and effectiveness of the system of science teaching and technical instruction. As a result, the systems of further, higher and vocational education and continuous professional development have grown up to support the formation of engineering competence.

As our economy recovers and rebalances, it is right to ask again whether the current arrangements for the provision of engineering skills are fit-for-purpose. In conducting this Review, I have spoken to many industrialists, professional bodies, and educators. I am grateful for all of their contributions. I am especially grateful for the support and detailed policy input received from the Royal Academy of Engineering.

This Review endorses the widely accepted view that it would benefit the economy to substantially increase the supply of engineers entering the labour market. It would add flexibility and resilience to our economy, and enable more people to take advantage of the new opportunities that technological change presents.

Over the longer term, if we accept that there will be a growth in demand for engineering skills as a result of growth and rebalancing of the economy, then we need to act. My report exposes a series of structural and behavioural barriers that must be tackled in order to improve the longer-term talent pipeline; this is especially the case in inspiring young people throughout their education. In addition, we should be concerned over the quality of parts of the supply system and pinch points that inhibit the development of the types of engineer which current and future industries require. There is also evidence of current shortage in specific areas: my report includes recommendations that could help the short-term position.

Finally, I am strongly of the view that this is not an agenda that Government alone can solve. Employers and professional bodies need to step up. Of my 22 recommendations, 15 require full and active engagement of industry, the profession and the education sector. I hope this report will be a **call to action** that will bring engineering employers, the profession and educators together, to own and collectively shape a future in which our supply of engineers grows in quality as well as quantity.

Yours
Professor John Perkins CBE FREng

Acknowledgements

In conducting this Review, and preparing my report, I have been assisted by a large number of individuals and organisations. I am especially indebted to the Royal Academy of Engineering, and in particular to Professor Matthew Harrison and Philip Greenish, both of whom have responded tirelessly to what must have seemed like endless urgent requests for data and advice on the engineering profession. The Institution of Engineering and Technology (IET) has provided help through seconding one of its very able staff, Stephanie Fernandes, to the project, and by convening several industry round-tables for us. Overall, the profession, through its major institutions, has been tremendously helpful.

I have been in BIS for nearly two years now, and I remain highly impressed by the quality and commitment of the staff of the Department. The number of colleagues who have helped during the course of the Review are too numerous to mention, but you know who you are – many thanks to you all for your help and support. However, one individual does merit a special mention. My deputy, Amanda Dickins, brought fresh energy to the project when she joined the Office of the Chief Scientist earlier this year. Her efforts have played a crucial role in bringing this project to its current state.

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Inspiration		
3.	The engineering community, including all the professional engineering institutions, should join in partnership with Tomorrow's Engineers, to agree effective core messages about engineering and cooperate to disseminate these messages to young people.	Tomorrow's Engineers, professional engineering institutions
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5.	High profile campaign reaching out to young people, particularly girls aged 11-14 years, with inspirational messages about engineering and diverse role models, to inspire them to become "Tomorrow's Engineers". The engineering community should take this forward as an annual event.	Government, engineering community
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6.	Government should ensure that the Royal Academy of Engineering (RAEng) and the Institute of Physics are fully engaged during consultation on revisions to A-level physics to ensure that the new A-levels will provide a sound foundation to progress to degree-level study in engineering.	Government, RAEng, Institute of Physics

7.	Government should continue to support schools to increase progression to A-level physics, especially among female students.	Government
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21.	Engineering employers should explore the potential for developing cooperative cross-sector schemes to support postgraduate students.	Employers, professional engineering institutions
22.	Government, through EPSRC, should seek further evidence of unsatisfied demand for engineers trained to doctoral level, and review arrangements for the support of PhD students in the light of their findings.	Government, EPSRC

1 Introduction

Engineers are the people who can create practical solutions to our 21st Century challenges of sustainability, housing and an ageing population. And we need more of them.

Sir James Dyson

Engineering is pervasive, woven through the fabric of our everyday lives. Engineering plays a vital role in creating not just our smartphones but also the network that keeps us connected and the music and apps we download. Engineering is built into the lighting and heating in our homes, and the grid and the power stations that keep them working. Engineering creates not just our cars but also the bridges, tunnels and roads that enable our cars to get us where we want to go. And engineering is embedded in our most extraordinary feats, enabling us to travel faster, explore further, to the depths of the ocean and into space.

As engineering drives technological progress, British engineering has a major opportunity. The ability to design and make things that the whole world wants to buy remains one of the cornerstones of our economy and one of the most important strategic levers at our disposal to create new growth, new jobs and renewed prosperity. Engineers are the perfect example of the sort of high-skilled, long-term jobs we want to encourage, jobs that will be critical to growing the British economy over the next decade. And we must not neglect the bigger challenges that the world faces in providing food, energy and clean water to an ever growing and ageing population. The deployment of engineering skills will play a crucial role in addressing these global issues.

Engineering skills are needed throughout the economy, in professional services, energy, transport, communications and construction, as well as in manufacturing. People who have studied engineering are also in demand to fill other occupations, as their analytical approach and project management skills are applicable in many environments. Demand for engineering skills, and the scientific and mathematical knowledge that underpins them, exists not only at the visionary end of design and invention, but all the way through the supply chain. The visions of John Logie Baird, Frank Whittle or James Dyson would never have become part of people's everyday lives the world over had it not been for the engineering skills of tens of thousands of employees who have turned their ideas into products.

Engineering businesses depend for their viability on their skills and on the abilities and ambitions of each new generation that joins the labour market. Many employers have been forced to look overseas for workers with the expertise and experience needed to sustain their businesses and it is clear that migration will continue to be an important source of engineering skills for some time to come. But it is up to us, together, to ensure that the right skills become readily available to employers at home, and that they are no longer obliged to look further afield for the highly-skilled professionals they need.

That task is made all the more pressing by the fact that, although unemployment overall has begun to fall, nearly a million 16-24 year-olds are still without a job. We owe it to our young people to equip them with the skills, including engineering skills, that British industry and the British economy needs now and will need in the future, and which can offer as many of them as possible rewarding and satisfying long-term careers. This Review highlights programmes that successfully attract new recruits to engineering. I have also looked at what more could be done, taking account of the continuing financial restraints on the public sector, to promote and support engineering skills.

Ensuring the supply of engineering skills is a long-term problem that we need to solve collectively. The solutions that I propose are long-term, working across Government and in partnership with employers and the engineering community. We also welcome the attention given to these issues by the devolved administrations.

Action on engineering skills in the Devolved Administrations

The Scottish Government is supporting the Scottish Resource Centre for Women in Science, Engineering and Technology (SET) to create sustainable change for women in SET sectors throughout Scotland, and the CareerWISE Scotland campaign to support girls and women to take up and retain jobs in STEM occupations. It has also encouraged Scottish universities to sign up to diversity schemes such as Athena SWAN.

The Welsh Government's National Science Academy (NSA) and sector work fund activities to engage young people in STEM, e.g. supporting Airbus to run an all girls cohort of Industrial Cadets. The Welsh Government is reviewing the curriculum including science and technology aspects and provides financial incentives for high quality STEM graduates to enter teaching. It is also investing in STEM apprenticeships and actively supporting the engineering sector to pilot and test new ideas.

In Northern Ireland, the Minister for Employment and Learning has formed an Advanced Manufacturing Working Group, bringing together Government, business and education to tackle skills shortages. The availability of engineering skills is a key issue for the Group: investigation is under way and they will be producing an action plan in early 2014. There is also a cross-departmental STEM skills strategy, 'Success through STEM', which has received strong support from business in promoting STEM and STEM careers.

Education and skills are devolved matters and the recommendations contained in this Review apply to England, although the improvement to engineering skills should benefit employers across all four nations and may have implications for organisations that operate across the UK, including the EPSRC and STEMNET.

The results of meaningful collaboration focused on meeting real workplace needs will ultimately be represented not only by improved statistics for employment, productivity and performance, but in lives made richer and more fulfilling. And by a world in which, once again, excellence in engineering is seen as a truly British characteristic.

2 The opportunity

There is clearly a substantial demand for engineers in the UK economy. Based on my examination of the evidence in the course of this Review, I endorse the widely accepted view that it would benefit the economy to substantially increase the supply of engineers, adding flexibility and resilience to our economy, and enabling more people to take advantage of the opportunities created by technological change. I agree with Sir James Dyson that we need more engineers.

I believe this because the structural changes in our economy have, and will continue to, drive demand for engineering skills. Over the last thirty years we have seen a widening gap between the wages and job prospects for skilled workers, compared to the unskilled. Under any plausible scenario for our future growth, new technology is likely to drive greater demand for higher, technical skills. Based on recent experience, it is likely to be those with a solid level of English, maths and problem-solving skills who will have the most chances to flourish. Engineering skills, with their strong maths and problem-solving component based on the application of science will clearly be very important.

Predicting with confidence the future supply and demand for engineers is a difficult exercise, being highly sensitive to modelling assumptions (see box). Nevertheless, there is enough evidence to support a need to substantially increase the supply of engineers, at both professional and technician level in the UK, and there is no room for complacency if we are to meet this goal.

Estimating demand and supply

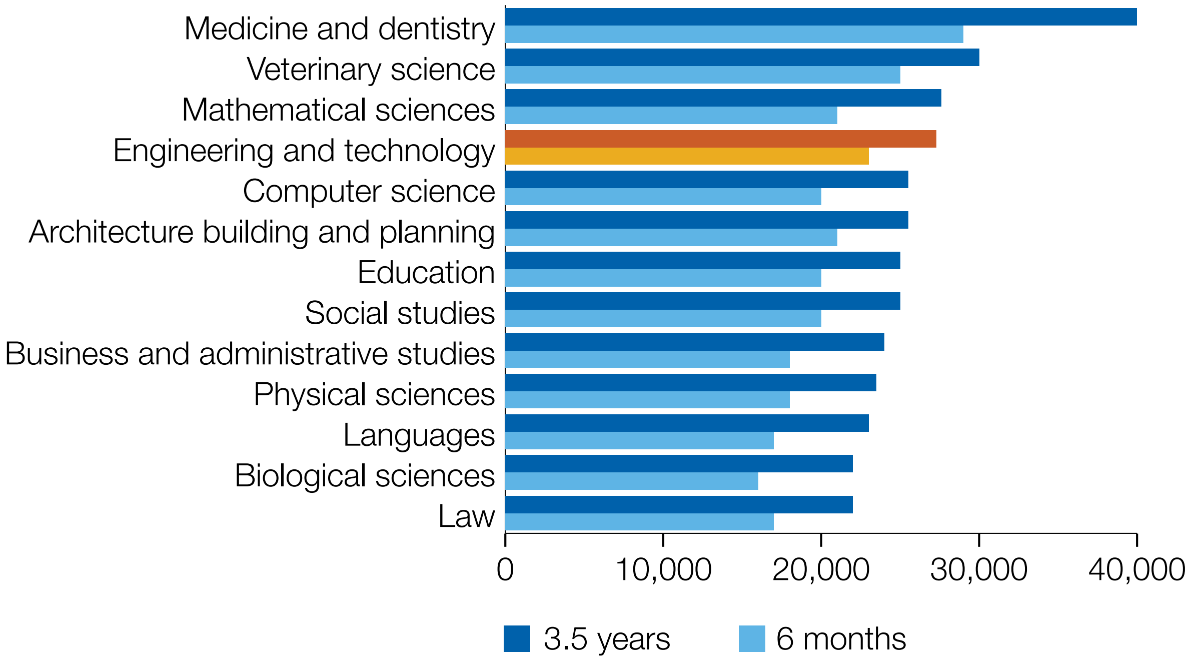
Estimating the future workforce demand and supply is tricky. For example, the authors of a 2013 UKCES report on the supply and demand for high level STEM skills acknowledge that their model is sensitive to assumptions about vacancy rates, minor adjustments to which can cause the model to predict skills gaps – or their absence.[1] *One of the most widely-cited estimates is the Royal Academy of Engineering's report on "Jobs and Growth", which forecasts that, between 2012 and 2020, the UK economy will require 830,000 professional scientists, engineers and technologists, largely to replace those leaving engineering practice e.g. through retirement. This works out at over 100,000 new professionals each year.*[2] *However, we should not assume that the supply relies solely on the provision of fresh STEM graduates. As the Royal Academy of Engineering points out in the same report, only 60% of current engineering professionals are educated to degree level. There are multiple pathways into engineering, including training within the workforce and conversions from those with qualifications in related subjects. The ranks of the UK's professional engineers are also boosted by people returning after a career break or working abroad – and further reinforced by inward migration, including from outside the EU.*

Short-term pressures

In the short-term we must ensure that recovery is not constrained by a lack of specific skills: employers are likely to experience increased difficulty recruiting when the economy picks up. We know that engineering graduates command a wage premium that is bigger than the average for graduates as a whole, and indeed for science graduates, and has continued to increase even as the average graduate wage premium has fallen in the UK.[3] Graduates with a first degree in engineering and technology earn a median salary of £28,500 three years after graduation, compared to a median salary across all science areas of £25,500. Only 8% of engineering and technology graduates earn less than £20,000, compared to 13.7% of all science subject graduates, and 17.8% of all graduates.[4] Some employers are filling gaps by working their current staff harder, putting senior staff on lower level jobs, turning down work and employing contractors. Unfortunately these problems may self-reinforce if senior staff are too busy to mentor or train recruits and staff leave due to poor work-life balance.[5]

1 UKCES Supply and demand for High Level STEM Skills, 2013.
2 Royal Academy of Engineering, Jobs and Growth: the imporance of engineering skills to the economy.
3 Greenwood et al, The labour market value of STEM qualifications and occupations, Institute of Education and Royal Academy of Engineering 2011.
4 HESA Longitudinal Survey.
5 Interviews conducted for UKCES Supply and demand for High Level STEM Skills, 2013.

Median annual salary by degree subject, 6 months and 3.5 years after graduation[6]



We also have evidence of shortages in some specific areas of engineering. As our economy rebalances, it will create increased demand for engineering and other types of skills. Industrial Strategy sectors are already identifying future growth opportunities, and note the need, for example, for systems engineers in the automotive sector and composite technicians in aerospace. It is no accident that there are skills pressures in sectors that have received substantial support: where we seek to facilitate growth, there we can expect an increased demand for skills. This is why each Industrial Strategy sector is undertaking specific skills planning. It is right that, instead of Government planning the skills needs of sectors, employers should collectively take ownership of the opportunities and, working with Government and the profession, shape the provision that is needed. This is why I recommend that, to tackle short-term pressures, we should invite employers to come forward with innovative proposals for developing skills in areas of shortage, for example by creating rapid conversion courses for those who have studied subjects other than engineering that nonetheless provide good foundations for engineering.

Moreover, the UK currently relies on inward migration for engineering skills: immigrants (EEA and non-EEA) account for 20% of professionals in strategically important sectors such as oil and gas extraction, aerospace, and computer, electronic and optical engineering.[7] The extent to which we rely on immigration for engineering skills is reflected in the Tier 2 shortage occupation list, which lists those occupations where

6 HESA Longitudinal Destinations of Leavers from Higher Education Survey.

7 NIESR, Skilled immigration and strategically important skills in the UK economy 2012. Not all companies can or want to use migration to fill skills gaps: the use of non-UK nationals is limited in some sectors, for example by security restrictions or concern about retention.

there are not enough resident workers to fill the available jobs. The shortage occupation list reflects the extent to which the on-going increase in demand for specialist engineering skills outstrips the potential supply in the short term: engineering jobs dominate the list, accounting for half of the 119 job titles, with a further 20% in closely related scientific and technical areas.[8] Meanwhile, engineering and technology subjects in UK higher education institutions recruit 32% of their students from overseas.[9]

Whilst this Review welcomes the fact that the Government allows employers to import engineering skills in key shortage areas, this should not be our long-term solution. I agree with the Migration Advisory Committee recommendation that Government, employers and partner organisations should be working together to address skills shortages in engineering. We should support the UK's young people by preparing them to compete for highly-paid skilled engineering jobs, improving their career prospects and reducing the need to import engineering skills.

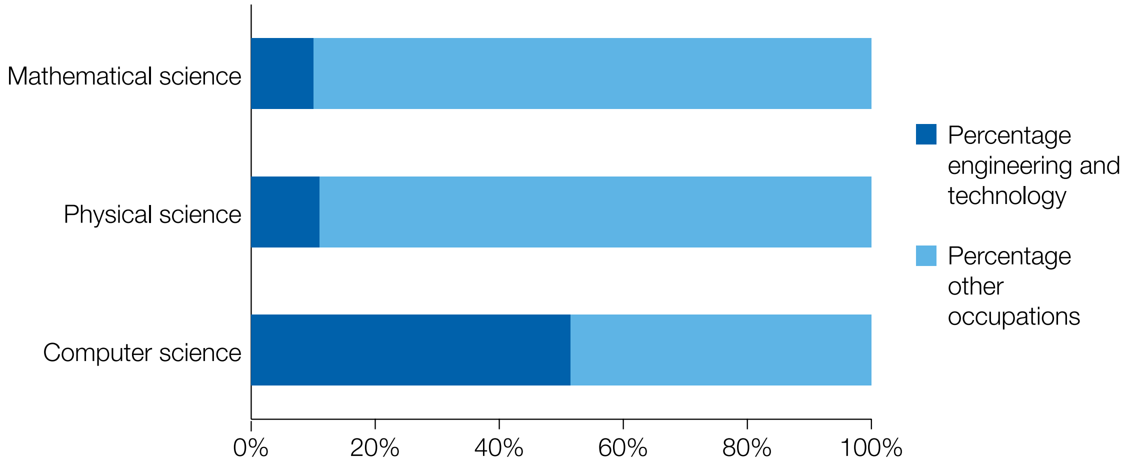
However, this is a long-term ambition, not a solution to short-term pressures. Engineering skills take a long time to develop, particularly when you take account of the time needed to develop the academic foundations of engineering by studying maths and science in school. In the short term, we can improve supply by investing in retaining those with engineering skills and encouraging them to return if they have left the profession or taken a career break. In the former category I commend the work done by Talent Retention Solutions (TRS) in developing a system that help the UK to retain valuable engineering skills, for example by supporting engineers to understand how their existing skills. In an ever-more rapidly evolving economy, TRS aids talent retention by supporting engineers to understand how their existing skills could be applied in new roles and different sectors. I have also been impressed by the fellowship scheme run by the Daphne Jackson Trust, which supports academics to return after a career break. I propose that we should explore the potential to set up a similar scheme for those returning to professional engineering after a career break. This would be of benefit to all who take career breaks but could be particularly useful if it helped to retain skilled women in the profession.

We also know that many engineers have backgrounds in closely related subjects. The chart below sets out the proportion of those who have studied mathematical, physical or computer sciences who have moved to work in engineering and technology occupations. Some of these will already have the skills and knowledge they need and some may "convert" by pursuing a second degree in engineering. It is my view that employers should be encouraged to develop innovative ways to support such "conversions".

8 Engineering jobs defined to include those where the Standard Occupational Classification (SOC) or job title included the words engineer or engineering.

9 HESA, Students in Higher Education Institutions.

UK domiciled graduates with degrees in other subjects entering engineering and technology occupations 2010/11[10]



What do we need to do?

Government should invite employers to put forward innovative proposals to develop engineering skills in sectors suffering acute skills shortages.

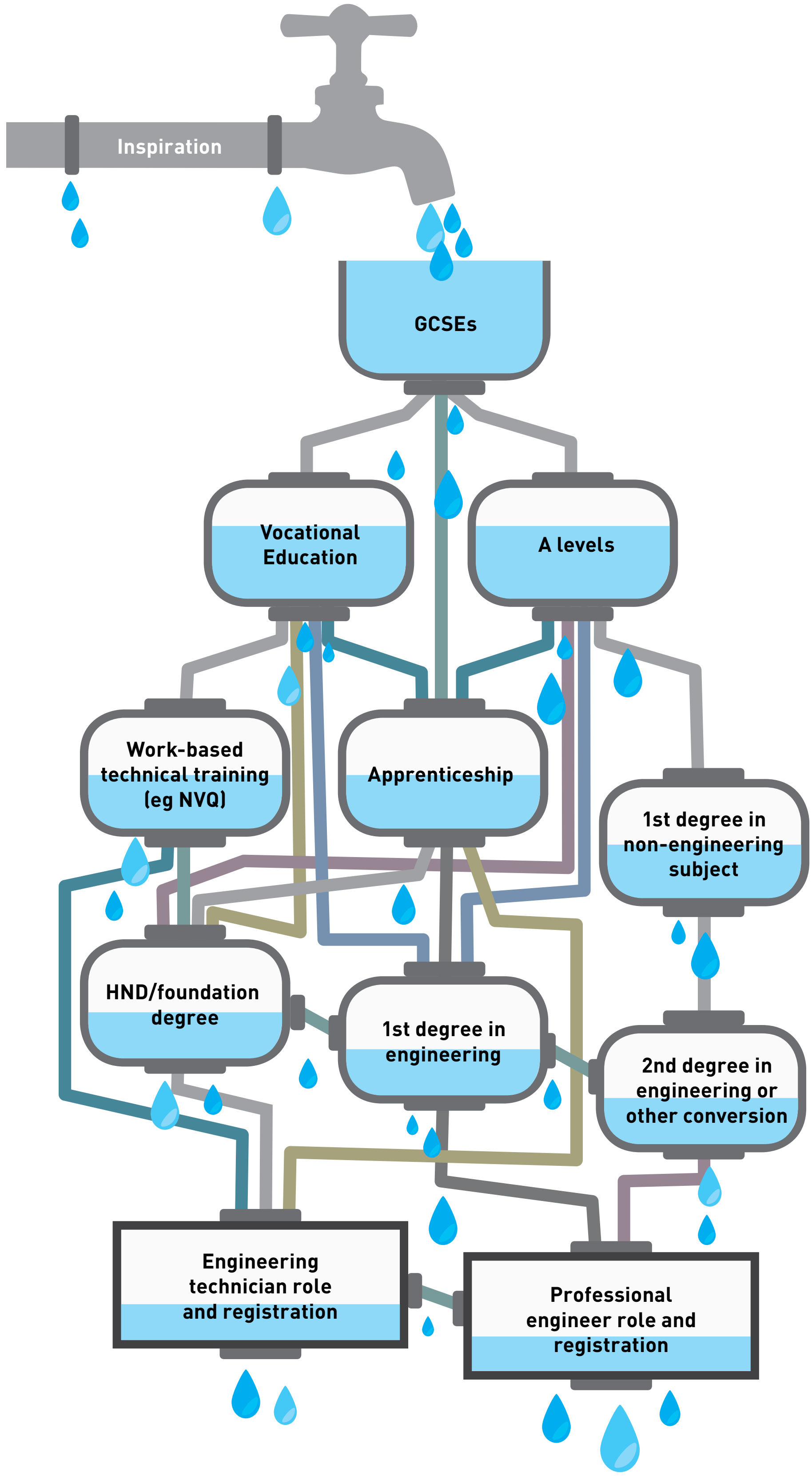
Government should support the Daphne Jackson Trust to extend and develop their fellowship model to support people returning to professional engineering after a career break.

Improving the long-term pipeline

While, in the short term, businesses 'make do' with the skill levels they inherit, in the long term, there is much more that we can do – and need to do – to ensure that our workforce has the right skills. I have undertaken an end-to-end analysis of the formation of new engineering skills, illustrated in the "pipeline" diagram below, which depicts both the multiple routes along which developing talent flows and the many points where it leaks from the system.

[10] HESA, Destinations of Leavers from Higher Education Institutions.

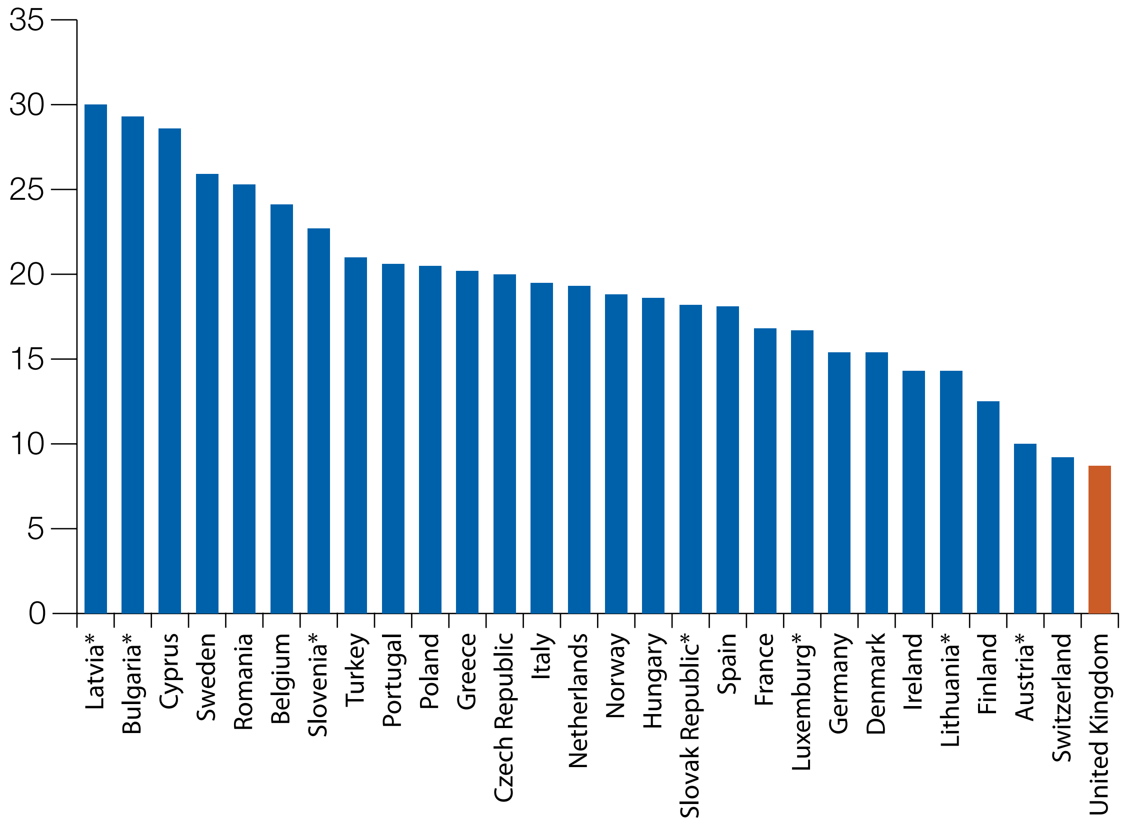
The pipeline for engineering skills leading to professional registration



We need to take action: from "priming" the pipeline by inspiring young people about engineering and giving them a strong academic foundation in school, to actions to tackle "leakage" and capacity and quality issues thoughout the pipeline. I also propose actions to enhance the reponsiveness of the system to employer needs, encouraging collaboration and engagement with educational institutions and boosting employer ownership of skills.

Diversity is a pressing problem and has been a consistently recurring theme throughout the course of my work on this Review. The lack of diversity remains an acute issue for engineering in the UK. There are a number of different groups that are under-represented in the talent pipeline. However, the lack of diversity is seen most starkly in the gender gap. The UK has the lowest proportion of female engineers in the European Union, less than one in ten engineering professionals is a woman. This is a crucial issue: engineering is failing to draw on the whole of the talent pool.

Percentage of female 'Engineering Professionals' in EU countries[11]



[11] UKRC analysis of the European Labour Force Survey, 2007. Asterisk = statistically less reliable.

Investigations into the causes of the UK's poor performance have highlighted girls' subject choices at 16 and perceptions of engineering as a career, which is sometimes reinforced by gender stereotypes in the careers advice received by students.[12] Rather than treat diversity as a separate issue, we have chosen to "mainstream" the issue and consider what can be done about it throughout the Review.

Conclusion

Engineering is a British success story. We have an enviable track record of producing world-class engineers and technicians. The way the global economy is changing should be good for engineers and good for Britain. However, we are at risk of not making the most of the opportunities that will come our way. As an engineer, I have looked at the whole pipeline and identified the areas where, in the short and long term, Government, employers, the profession and educational institutions must act if we are to secure our engineering future.

[12] EngineeringUK, An investigation into why the UK has the lowest proportion of female engineers in the EU, 2011. See also Institute of Physics, It's Different for Girls: The Influence of Schools, 2012.

3 Inspiration and academic foundations

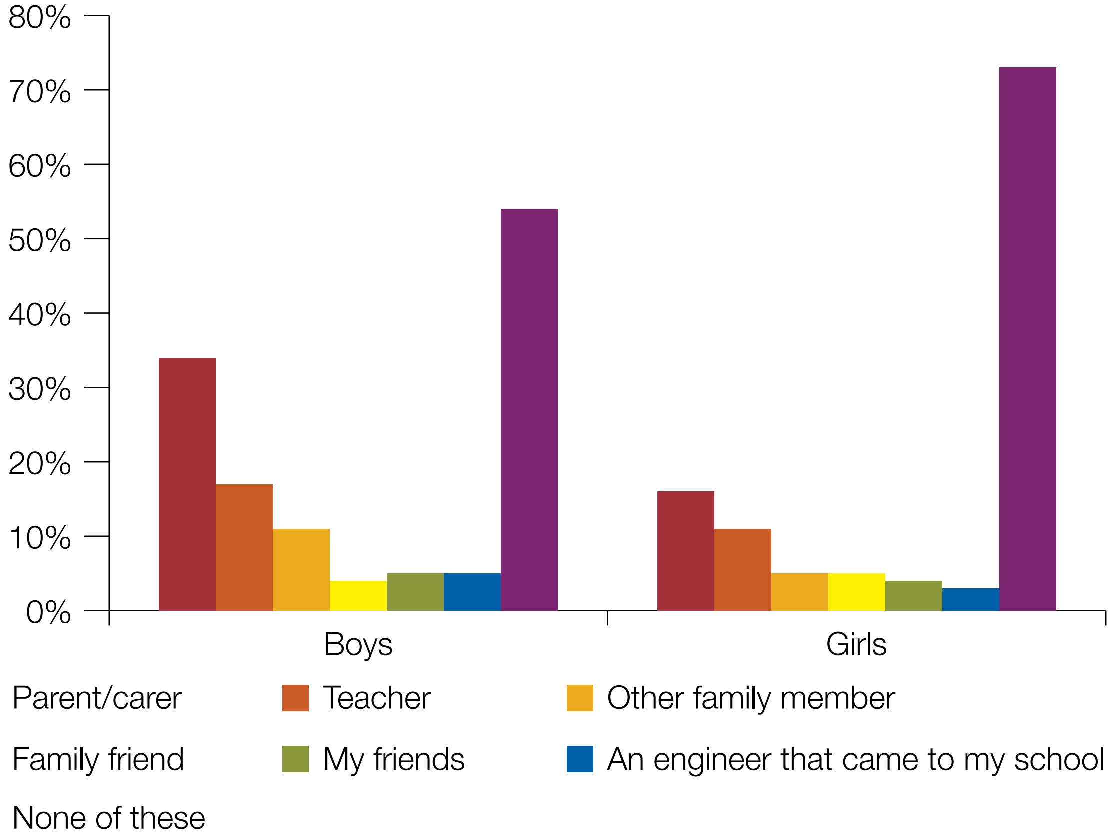
Introduction

If we are going to secure the flow of talent into engineering, we need to start at the very beginning. We need young people who are technically and academically competent, but who are also inspired by the possibilities of engineering. Starting to inspire people at 16 years old is too late; choices are made, and options are closed off well before then. So we need purposeful and effective early intervention to enthuse tomorrow's engineers.

Inspiring young people and helping them to understand where different choices could take them in the future is crucial if engineering is to be able to draw on the full talent pool. There has been some progress in recent years: for example, the percentage of secondary school age children who would consider a career in engineering increased from 29% to 46% between 2011 and 2013.[13] However, the engineering profession continues to suffer from widespread misconceptions and lack of visibility that deter young people, and especially girls, from pursuing it as a career. In polling carried out for Tomorrow's Engineers Week, more boys reported being encouraged to think about engineering as a career, particularly by their parents (see chart).

[13] EngineeringUK 2013, 2012 Engineers and Engineering Brand Monitor.

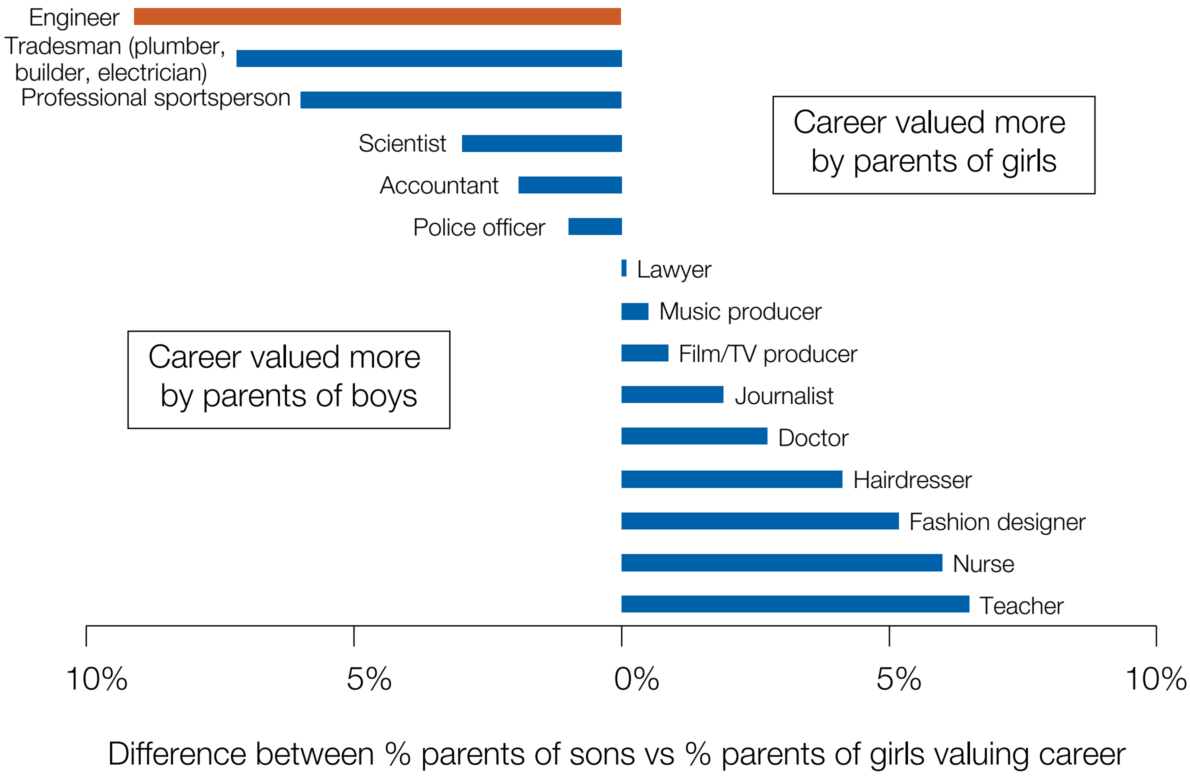
Who has encouraged boys and girls to consider a career in engineering?[14]



And this is reflected in what the same poll heard from their parents. Parents were asked what type of job they would most like their child to pursue. Some jobs, such as being a lawyer, were gender neutral: parents equally keen on law as a career whether they had boys or girls. However, as shown in the chart below, there was a 9% gap between parents of boys and parents of girls when it came to engineering, the biggest "gender gap" for any job.

[14] Polling for Tomorrow's Engineers Week.

Which career would parents most like that child to pursue?



As well as being inspired to consider engineering, our young people need the solid academic foundations to engage in the subject. Maths and science are the key gateway subjects for engineering.[15] As a result, we need to make sure that as many young people as possible are studying rigorous curricula in maths and science (especially physics) and/or high-quality vocational qualifications. They will need to be supported by excellent teaching, with strong subject knowledge. We also need to make sure that young people are inspired by engineering careers and the wider opportunities opened up by their study of science, technology, engineering and maths (STEM).

All engineers need a strong foundation in maths, whether they follow an academic or vocational route to becoming an engineer. However the UK lags behind its competitors in post-16 maths participation, creating a 'maths gap' between 16 and 18 for many students. Only about 20% of students in England study maths after GCSE, significantly lower than comparable countries: 48% of Scottish students study maths post-16, in the US the figure is over 65% and it is over 90% in Germany.[16] The OECD's recent survey of adult skills estimated that 8.5 million, roughly a quarter of England's adult population, have the maths skills of a 10-year-old, able to tackle

[15] The precise requirements will vary depending on which pathway a young person takes. For those choosing an academic route, Royal Academy of Engineering data shows that, for the years 2007-2010, 90% of applicants accepted onto Mechanical Engineering degrees at Russell Group universities held A-level maths and 78% held A-level physics. The numbers are lower for other engineering disciplines and other universities.

[16] Nuffield Foundation report Towards universal participation in post-16 mathematics 2013.

only one-step tasks in arithmetic, sorting numbers or reading graphs. The same survey showed that our young people are falling behind: 16 to 24 year olds in England score lower on basic skills than their grandparents' generation.[17] This poor performance limits the pool of people able to work in engineering both at technician level and at professional level.[18]

One of the main reasons for the low number of women in engineering in the UK is girls' subject choices in school.[19] In recent years there has been a significant increase in the number of students studying three individual sciences at GCSE and, at GCSE, there is now no gender gap. Girls are now equally or more likely than boys to attempt and achieve an A*-C grade in mathematics, core or additional science, and in each of the three individual sciences.[20] Entry for all three sciences rose in the summer 2013 GCSE results. This rise was largely driven by an increase in the number of girls: physics GCSE entries by girls are up 6.5% in 2013 to 78,000.[21] Mathematics GCSE entry has increased 12.5% to 760,000 in 2013, although, the percentage of entries achieving A*-C has dropped slightly.

However, a significant gap starts to widen at A-level: only 40% of those taking A-level maths were female and only 30% of those taking further maths. Moreover, despite improvements at GCSE level, far too few girls continue to study physics through to A-level. The gender gap in physics remains striking: it is the second most popular A-level subject for boys in England, but only 17th amongst girls.[22] 49% of state funded co-educational schools in England failed to enter a single female candidate for A-level physics.[23] The gender gap in A-level physics constricts the number of women in the talent pipeline for engineering as well as the physical sciences. In 2012, 17% (362) of all state-funded schools and colleges did not have any A-level physics entrants.[24]

17 OECD Programme for the International Assessment of Adult Competencies survey of Adult Skills 2013.

18 Skills for Life 2011.

19 EngineeringUK, An investigation into why the UK has the lowest proportion of female engineers in the EU, April 2011.

20 Statistical First Release: Provisional GCSE and equivalent results and national curriculum teacher assessments at key stage 3 in England: academic year 2012 to 2013, October 2013.

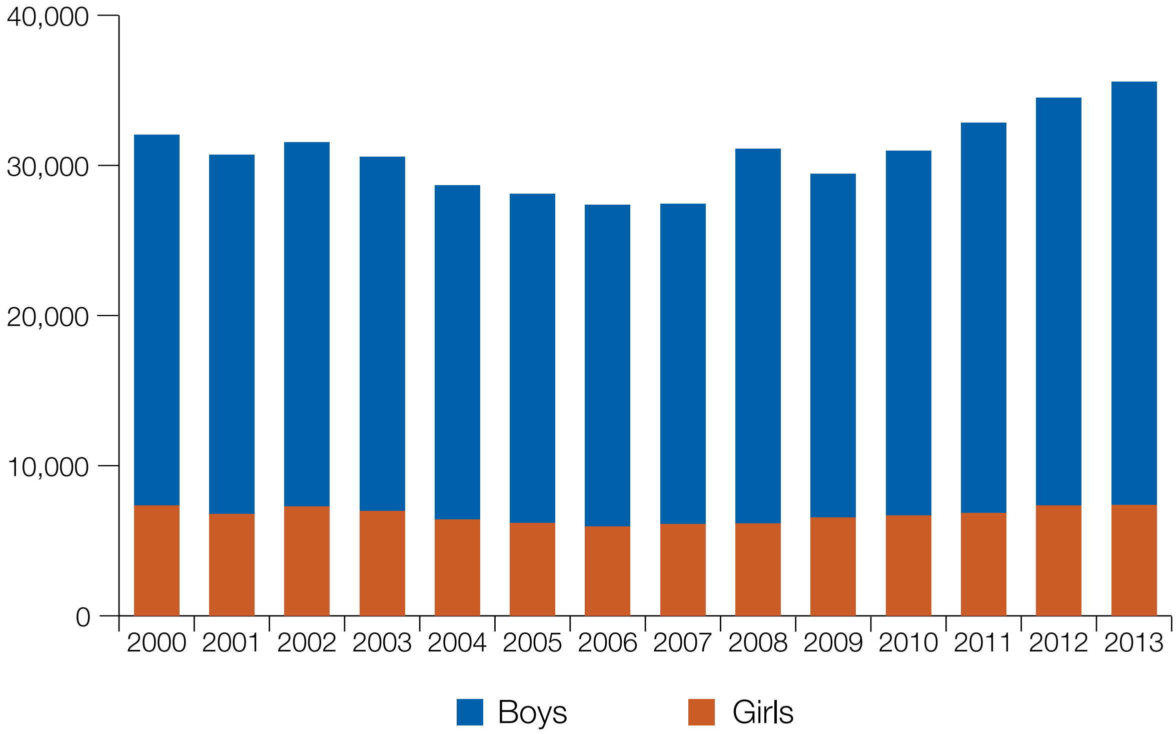
21 JCQ GCSE and Entry Level Certificate Results Summer 2013.

22 *www.jcq.org.uk/examination-results/a-levels* The situation varies in the Devolved Administrations, for example, Northern Ireland has a much higher proportion of girls taking A-level physics.

23 Institute of Physics, It's Different for Girls: The Influence of Schools, 2012.

24 Based on institutions with more than 10 Year 13 students.

A-level physics candidates by gender[25]



What are we doing?

Inspiration

Widespread recognition of the need to inspire young people and increase their awareness of the opportunities in engineering has prompted a wealth of initiatives by professional institutions and other voluntary organisations. This has created a complex and sometimes confusing landscape: a recent effort to collate materials identified over 70 different items being sent out to schools. As well as being inefficient, it is also ineffective because it is difficult for busy school staff to navigate this landscape, especially when messages are not coordinated. I welcome the efforts of the Royal Academy of Engineering and EngineeringUK to bring the professional engineering institutions together under the Tomorrow's Engineers "brand" to coordinate the engineering community's outreach to and engagement with schools. We should ensure that coverage is widespread, efficient and that messages are carefully crafted, based on the best available evidence about how to influence and communicate effectively with young people. It is also vitally important to ensure that teachers understand engineering and are aware of the opportunities it can afford their students. For this reason, I wholeheartedly support the Royal Academy of Engineering's STEPS at Work initiative: each year this important programme enables

[25] JCQ A, AS and AEA Results.

1300 teachers to spend a day at a local engineering firm, seeing for themselves industry in action.

The best motivation and advice come from people in jobs. Employers have a role in giving young people more real-life contact with the world of work.[26] In the Review, there were a number of views expressed about whether this is easy. Some businesses have noted barriers to effective engagement with schools; while others claim that they could spend every day showing schools around their plant. My own view is that we need to start from the perspective of the school, and design our interventions so that they are as easy as possible for schools and pupils to access. I have been impressed by the employer engagement programme under development by Tomorrow's Engineers. This programme works with the professional engineering institutions and STEMNET, to engage employers to provide industry visits, workshops, STEM Ambassador partnerships and careers resources, to incorporate engineering into pupils' experience and plant the seeds needed to grow the engineering talent needed by businesses. The programme has run successful regional pilots: I recommend that Government should support this valuable work so that it can be rolled out nationwide as soon as possible.

Curriculum

Government has placed clear priority on maths education, investing in challenging new curricula and rigorous assessments, as well as setting out a clear ambition that the overwhelming majority of students should continue to study maths until 18. The reforms will mean that more students will leave school able to reason mathematically and to apply their knowledge to solve problems, providing them with a much improved foundation for engineering.

Engineers also need a foundation in science, including a good understanding of physics. Government is working to ensure that students are offered the opportunity to study high-quality specialist science and are encouraged to take it up, making sure they understand how specialist science opens up career opportunities. Government has reformed the science content in the national curriculum, focusing on core essential knowledge and requiring students to demonstrate stronger mathematical skills. New, more rigorous science GCSEs will be introduced from 2016. A new GCSE in computer science has been created along with a new computing curriculum that focuses on teaching students the fundamentals of programming and creating technology instead of just being IT consumers. A welcome feature of these developments is the engagement of the computing and engineering professions in an effective partnership with Department for Education, coordinated by the British Computing Society, the Chartered Institute for IT and the Royal Academy of Engineering.

[26] Matthew Hancock, Inspiration Vision Statement 2013.

In the same spirit, I very much welcome the revisions that have been made to the Design and Technology National Curriculum in full consultation with the engineering profession and others, to make it more consistent with 21st century needs. Design and Technology is not compulsory but remains a highly popular GCSE, and gives young people the chance to learn about engineering principles before the age of 16.

The Government has allocated £5 million to support the Stimulating Physics Network (SPN) to reach more schools and widen participation in physics by groups that are currently under-represented, including girls and those living in disadvantaged areas. The programme has been successful in raising progression rates: these have risen faster in the schools it has been working with relative to the national average, particularly in relation to girls.

Last but not least, Government is reforming A-levels, by giving more control to universities, to ensure that A-levels provide the right foundation for progression into HE in relevant subjects. It is important, however, that this process take account of the fact that more A-level students go on to study engineering at university than progress to physics. According to analysis of UCAS data by the Institute of Physics, 9.7% of higher education accepted applicants with physics A-level entered a physics course, compared to 25.4% who entered engineering degrees.[27] A consultation on the subject content of A-levels, including science, was launched on 25 October 2013. The aim is that the subjects included in the consultation will be ready for first teaching in September 2015.

Teachers

Reforms to curriculum and qualifications are not enough on their own. High-quality teaching is critical to student engagement and success in the important but challenging subjects that create the foundation for engineering (maths and physical sciences, and also computing and design and technology). Government has introduced bursaries of up to £20,000 and prestigious scholarships worth £25,000 (awarded by the Institute of Physics, the Institute of Mathematics and its Applications, the Royal Society of Chemistry, and the BCS, the Chartered Institute for IT), to attract more physics, chemistry, maths and computer science graduates into teaching.

It is also important to continue to strengthen the capability of the teaching workforce. The National Centre for Excellence in the Teaching of Mathematics and the regional network of Science Learning Centres provide maths and science teachers with high-quality professional development opportunities. Government has provided support to Imperial College to develop a one-year course for teachers of A-level maths to improve their subject knowledge, confidence and how they teach advanced material. Government is also working with the BCS to develop a Master Teachers network to support continuing professional development. BCS is also seeking to engage

[27] Institute of Physics, Degree-Course Destinations of Accepted Applicants with Physics and Mathematics A-level or Scottish Higher 2006–2011.

employers in mentoring teachers, including via the informal links established by involving employers in interviewing prospective trainee teachers.

What do we need to do?

Inspiration

Engineering has a powerful and inspiring story to tell. But a better coordinated and more purposeful approach is needed. So I recommend:

> The engineering community, including all the professional engineering institutions, should join in partnership with Tomorrow's Engineers, to agree effective core messages about engineering and cooperate to disseminate these messages to young people.
>
> Government should provide seed funding to develop nationwide roll-out of the Tomorrow's Engineers employer engagement programme. Government should also encourage and help schools and colleges to connect with employers.
>
> A high profile media campaign reaching out to young people, particularly girls aged 11-14 years old, with inspirational messages about engineering and diverse role models, to inspire them to become "Tomorrow's Engineers". The engineering community, should take this forward as an annual event.

Academic foundations

Government's actions to improve maths, science and technology provision, at GCSE and A-level, are based on sound goals. However, the approach could be strengthened as follows:

> Government should ensure that the Royal Academy of Engineering and the Institute of Physics are fully engaged during consultation on revisions to A-level physics to ensure that the new A-levels will provide a sound foundation to progress to degree-level study in engineering.
>
> Government should continue to support schools to increase progression to A-level physics, especially among female students.
>
> Government should focus on teacher recruitment to shortage subjects and also promote physics with maths to schools involved in teacher training.

The engineering community should provide continuing professional development for teachers, giving them experience of working in industry to develop the knowledge to put their academic teaching in practical context, enlivened with practical examples, as well as enabling them to inspire and inform their students about engineering.

Conclusion

To increase the supply of engineers in the UK, our young people should be provided with a solid academic base and inspired by the opportunities that engineering has to offer. My Review shows that there has been substantial progress, but that there are particular areas where further action would be beneficial. Addressing these will help to ensure that the next generation of engineers have the best possible start, whether they take a vocational or academic route into the profession. It will also give all young people more chances to see and understand the importance and value of technical skills.

4 Vocational Education

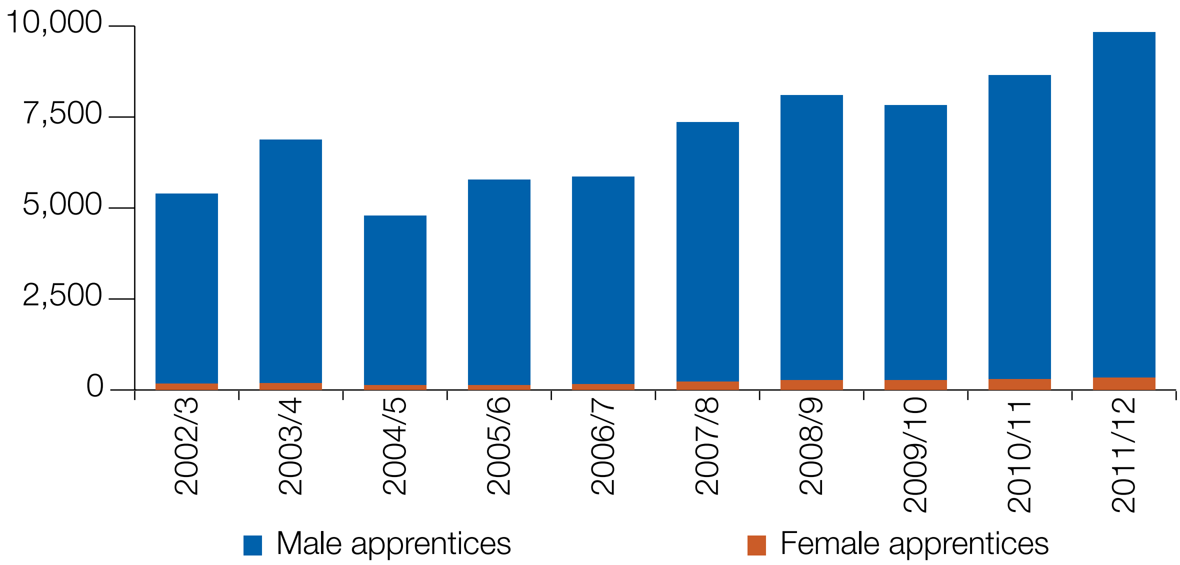
Introduction

There are two principal pathways into engineering: the academic route through higher education, and the vocational route through apprenticeships, further education and other work-place based training. There are many leaders of great British manufacturing companies who began as an apprentice and built their careers via the vocational route. This is one of the great strengths of the profession.

The provision of engineering technicians is one of those areas where industry has highlighted a potential under-supply, and there may be particular vulnerability as manufacturing recovers. Equipping people to become engineering technicians can be a relatively quick process when compared to acting on the long-term supply through schools or universities. A responsive vocational education system should be able to act rapidly to deal with new skills needs as they appear.

Indeed, the UK system has been responding to increased demand for apprentices, as show by the recent growth in numbers of starts for the engineering frameworks.

Advanced and Higher Apprenticeship starts in engineering[28]



[28] ONS.

However the chart also shows how few women are taking engineering apprenticeships. In the 2011/12 academic year in England, only 400 women started the engineering framework apprenticeship, compared to 12,880 men. And the gender gap found in apprenticeships is also found in other types of vocational qualifications in engineering.

Government is reforming vocational education to ensure that it provides high-quality, rigorous qualifications that respond to employer needs. I believe that these reforms – by improving responsiveness and by structuring better, higher-skill pathways – can deliver important improvements in the scale, esteem and quality of vocational engineering skills.

What are we doing?

Ensuring a responsive system

Government has freed up the Further Education (FE) system. It has allowed colleges and private sector providers to respond more effectively to local demand conditions. However, in the course of my work on this Review I have heard evidence of mismatches between what local business needs, and what local FE provides. I have also heard examples of where FE colleges have been unable to put on provision to support local job opportunities because the funding rules have been inflexible; even where the employer is willing to foot most of the bill.

Given the opportunities that can be created through retraining people who already have basic science and maths skills, the lack of responsiveness in the system could hold us back. So innovative approaches that would permit greater flexibility could be especially valuable. As a result, I have been encouraged by Government's recent experiment with the Employer Ownership Pilot (EOP). The EOP is a £340 million competitive bidding fund that invited employers, over two rounds, to tell Government how they would better use public investment, alongside their own, to invest in the skills of their current and future workforce in order to grow our economy. Already the first round of EOP projects have started to deliver training to over 470 individuals in engineering and manufacturing projects. This approach has the merits of being flexible, targeted, and employer-driven.

I have also been struck by employer views that, given the rapid changes in technology, our vocational institutions are not sufficiently equipped to prepare young people for future production techniques. Greater specialisation, with the potential for elite provision, could help address deficiencies in our high-level technical skills and help to raise the status of vocational education as a pathway to a worthwhile career.

Government has already made a strong start by fostering the creation of University Technical Colleges (UTCs) to provide high-quality education for 14-19 year olds with a clear focus on employment. Employer engagement lies at the heart of the model, ensuring that students develop the key practical and technical skills that employers need. UTC students also study a core academic curriculum that prepares them to undertake a higher level apprenticeship and/or university degree. Engineering is a key focus for the UTCs: of the 44 UTCs that are open or near completion, 33 have engineering as a specialism.[29]

Examples of UTCs with an engineering focus

The very first UTC to open, the JCB Academy, focuses on delivering high-quality engineering and business education in partnership with engineering employers such as Rolls-Royce, Bombardier, Network Rail, Toyota, Bentley and National Grid in addition to JCB.

The Aston University Engineering Academy embeds an employer-led engineering curriculum into 14+ education. Six engineering learning themes include: communications, energy futures (E.ON, National Grid); Transport (JaguarLandRover); Metrology; Design (PTC); and Environmental. Each theme will be supported by an innovation centre which will help students follow a project through all the steps from creation to sale.

Visions Learning Trust (Burnley) specialises in engineering and construction, supporting advanced manufacturing employers within the aerospace supply chain, the nuclear industry and green utilities and technologies. Learners will solve real problems from particular industries via termly employer-led projects.

Between UTCs and the development of higher apprenticeship frameworks, there is the beginning of a new vocational pathway for young engineers. It will be possible for a young person to start at a UTC, take a strong set of GCSEs, move on to A or Tech levels, and then move on to a higher apprenticeship and/or a university degree. This is an exciting development and one that could make a real difference to fostering engineering skills in this country. Adult vocational education should capitalise on these developments: I recommed the development of elite vocational provision for adults to sit at the pinnacle of this promising engineering pathway.

Apprenticeships: professional registration and Trailblazers

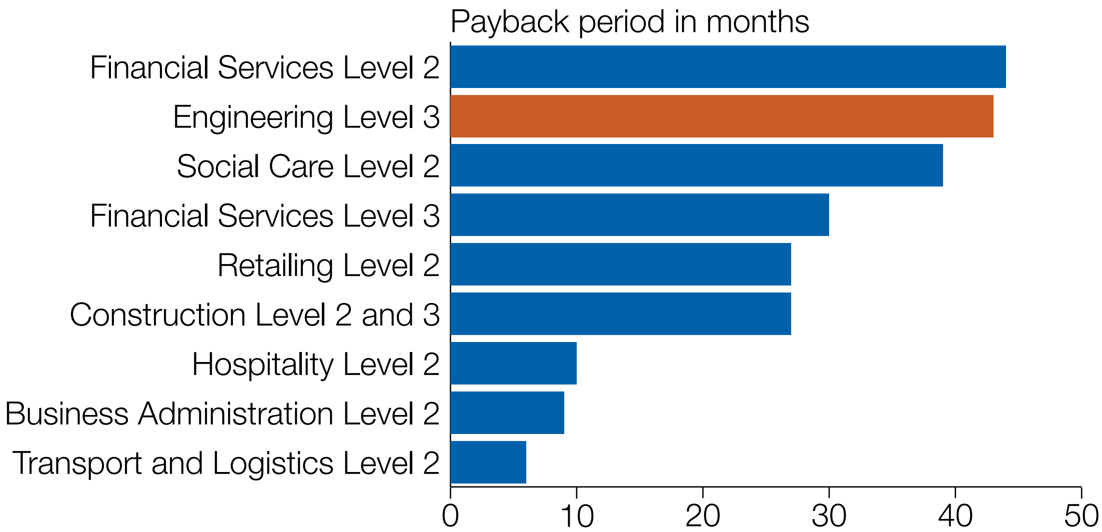
Engineering-related industries have long depended on apprenticeships for the supply of skilled staff. Despite the pressures that the recession has placed on public finances, the last three years have seen an unprecedented level of investment in apprenticeships. Higher Apprenticeships are being expanded, with investment in new frameworks to degree level and beyond. To support this, the Prime Minister launched a £25 million Higher Apprenticeship Fund in 2011, and it is funding around 30 projects with the aim

29 This includes five UTCs that have both computing/ digital technologies and engineering as a specialism and a further four that have either computer science/digital technology/media as a specialism.

of delivering 22,000 Higher Apprenticeship starts by 2015. New Higher Apprenticeships will be available in sectors including construction, advanced engineering, environmental technologies, energy and utilities (water and waste), and space engineering.

However, learner demand for apprenticeships outstrips supply: because an apprenticeship is a real job, growth is limited by employer demand for apprentices. Already there are 11 applicants for every place on the programme. The high cost of engineering apprenticeships means that some employers only take enough trainees for the short term rather than consider longer-term skills requirements. As the chart below demonstrates, it takes over 3.5 years (43 months) to recoup the investment in an engineering apprenticeship.

Length of time to recoup the cost of an apprenticeship[30]



On-going reforms following the Richard Review should help to improve the quality of apprenticeships, making them more responsive to employer needs.[31] Other methods may also help: some larger employers, such as Rolls-Royce, JaguarLandRover and BAE Systems, share training facilities with their supply chain and other local firms. In addition, many Group Training Associations (GTAs) have consistently delivered successful programmes of work-based learning in the engineering industry, governed by and influenced by employers.

For the future, Government sees its main challenge as ensuring that an expanded apprenticeships programme is sufficiently rigorous and embodies a sufficiently clear focus on quality to deliver all it promises both to employers and to individuals. The funding system is being reformed to put employers in the driving seat, empowering them to decide how apprentices are trained. Employers will also play a key role in setting clear standards: as the primary users of the skills acquired through

30 Employer Investment in Apprenticeships and Workplace Learning: The Fifth Net Benefits of Training to Employers Study. BIS research paper number 67.

31 www.gov.uk/government/consultations/future-of-apprenticeships-in-england-richard-review-next-steps

apprenticeships, and the final arbiters of how closely or otherwise those skills match the needs of a particular industry, it makes sense that the main responsibility for defining the standards that apprentices are expected to reach should lie with employers themselves.

Registration of Engineering Technicians (EngTech)

In June 2013 the Prime Minister announced a new initiative that aims to create 100,000 registered engineering technicians by 2018 to tackle the shortage of skills in several sectors. The multi-million pound initiative is a national drive to encourage young people to sign up to an engineering apprenticeship leading to registration. This will create a whole new generation of engineering technicians, giving them structured on-the-job training built upon a recognised academic qualification leading to EngTech designation. Working through new and established apprenticeship schemes, the initiative has been created by the Institution of Engineering & Technology, the Institution of Mechanical Engineers and the Institution of Civil Engineers and is backed by significant funding from the Gatsby Foundation.

Engineering has much to gain from these reforms, and I am pleased that when the Prime Minister announced the first wave of Trailblazer Apprenticeships on 28 October 2013, engineering sectors were at the forefront.

The professional engineering institutions have an important role to play to help guarantee the quality of provision, and to enhance the status of the apprenticeship route into engineering. Extension of the accreditation systems in place for university courses in engineering to apprenticeship schemes is an important development, as is the promotion to apprenticeship 'graduates' of the benefits of registration.

Registration of engineering technicians (see box) will help to address the severe shortages that face this cohort – a strong technician register is likely to raise awareness and increase the status of technician occupations, thus encouraging more young people to pursue careers in technician roles. In addition, registration has a strong focus on transferable skills and professional development, thereby helping individuals to adapt easily to technological developments in the workplace, helping to prevent further skills gaps from occurring. Technician registration provides a clear route into and through the engineering profession and is the first rung on the ladder towards Incorporated or Chartered Engineer status. Benefits to the individuals include improved recognition, earnings potential and career prospects.

Diversity

Some talented women have already followed the apprenticeship route into engineering, yet the latest figures available show that, in 2013, less than 1 in 30 of those starting an engineering apprenticeship were female. The Skills Funding Agency has responsibility for delivery of the apprenticeships programme, and increasing the diversity of apprenticeship applicants is a priority. Last year the Agency funded pilots across the country to test new delivery methods to engage more individuals from under-represented groups in apprenticeships. Following evaluation of these pilots, the Agency has commissioned additional research on gender and apprenticeships. The research will be published later this year and Government should use this to develop future plans to increase the diversity of apprenticeships.

Reforming vocational qualifications

Reform of apprenticeships is leading the way for wider reform of vocational education, emphasising quality and making skills providers accountable to those whom they serve.

Engagement from employers and the professional engineering institutions is critically important to making this responsiveness work as intended, ensuring that vocational education is preparing students for successful engineering careers. Our main concern is that employers themselves should take responsibility for the content of the training that prospective new entrants receive and the currency of the qualifications that they gain. Engineering's long history validates this approach, notably through its championing of apprenticeships and other forms of work-based training.

Government is implementing reforms to improve vocational education for young people. These include the introduction of Tech Levels (Level 3 vocational qualifications backed by industry) as a high-quality alternative to A-levels. Excellence will be recognised through a new performance measure, the Technical Baccalaureate (TechBacc), which will report students completing advanced (Level 3) programmes that include an approved Tech Level qualification, the new post-16 core maths qualification and an extended project. The TechBacc measure will incentivise the development of high-value vocational education and encourage the most able students to study demanding technical programmes.

Government's wider reforms to performance tables aim to incentivise schools and colleges to focus on high-quality, rigorous qualifications that enable progression to further study and employment opportunities. Government is encouraging awarding organisations to submit qualifications in sectors that are under-represented in performance tables, including manufacturing, construction and engineering. For example, the Royal Academy of Engineering has already led work to develop a suite of successors to the Level 1 and 2 Diploma Principal Learning qualifications in engineering. Two new Level 1 and 2 qualifications in engineering have been accredited by Ofqual and submitted for approval for the 2016 Key Stage 4 performance tables. Further qualifications for 14-16 year olds are expected to follow and the Royal Academy of Engineering has initiated discussions on the development of a new Level 3 qualification in engineering. Government will seek to continue this work with the engineering sector to promote development of high-value vocational qualifications at both Level 2 and 3 for post-16 students.

Strengthening teaching in the wider FE system

Not everyone will be able to secure an apprenticeship or attend an elite vocational institution. Many students will continue to pursue college-based courses in the wider FE system. Stronger collaboration between industry and local FE colleges would help teaching staff understand and embrace up-to-date workplace skills needs. Provision of mentoring and work experience to students can increase the aspirations of learners to progress.

Employers can have a very direct impact on the quality of vocational training by releasing their employees to participate in the Education and Training Foundation's "Teach Too" programme. Teach Too enables colleges to secure up-to-date occupational expertise by encouraging working people to teach for a few hours a week. By becoming directly involved in teaching in their local FE colleges, employers can help to ensure that learners are being trained in the latest industry standard skills.

Alongside more rigorous vocational qualifications, Government is working to ensure that young people are offered high-quality and meaningful work experience. From September 2013, work experience forms an essential part of 16-19 study programmes undertaken by students. A recent survey of FE colleges indicates that the number of work experience placements offered in the engineering sector is lower than some others, suggesting further development is needed in this area.

What do we need to do?

The vocational route into engineering is an under-exploited asset for the profession. In this area there is real opportunity for the sector to take advantage of the new FE freedoms and flexibilities and take ownership of future skills needs. Based on the Review, I have identified the following actions that could make a real difference:

> The engineering community should work with Government to develop and promote new Level 2 and 3 qualifications that will create high-quality vocational routes for 16-19 year olds to enter engineering careers.
>
> The engineering community should work with employers to encourage and support provision of work experience for post-16 students, studying in colleges and schools.
>
> The engineering community, especially employers, should work with Government to develop additional Trailblazer Apprenticeships in engineering.

Government should develop plans to boost diversity of engineering apprentices, building on the pilots and research commissioned by the Skills Funding Agency.

Government should build on the UTC experience and seek to develop elite vocational provision for adults so that our people have the opportunity to learn the very latest techniques and approaches in a vocational setting.

Engineering employers should encourage their staff to share their skills and knowledge, for example, by participating in the Education and Teaching Foundation's Teach Too scheme.

Government and the FE sector should encourage the application of learning technologies to extract maximum value from expert lecturers and the materials they produce, for example through Teach Too.

Conclusion

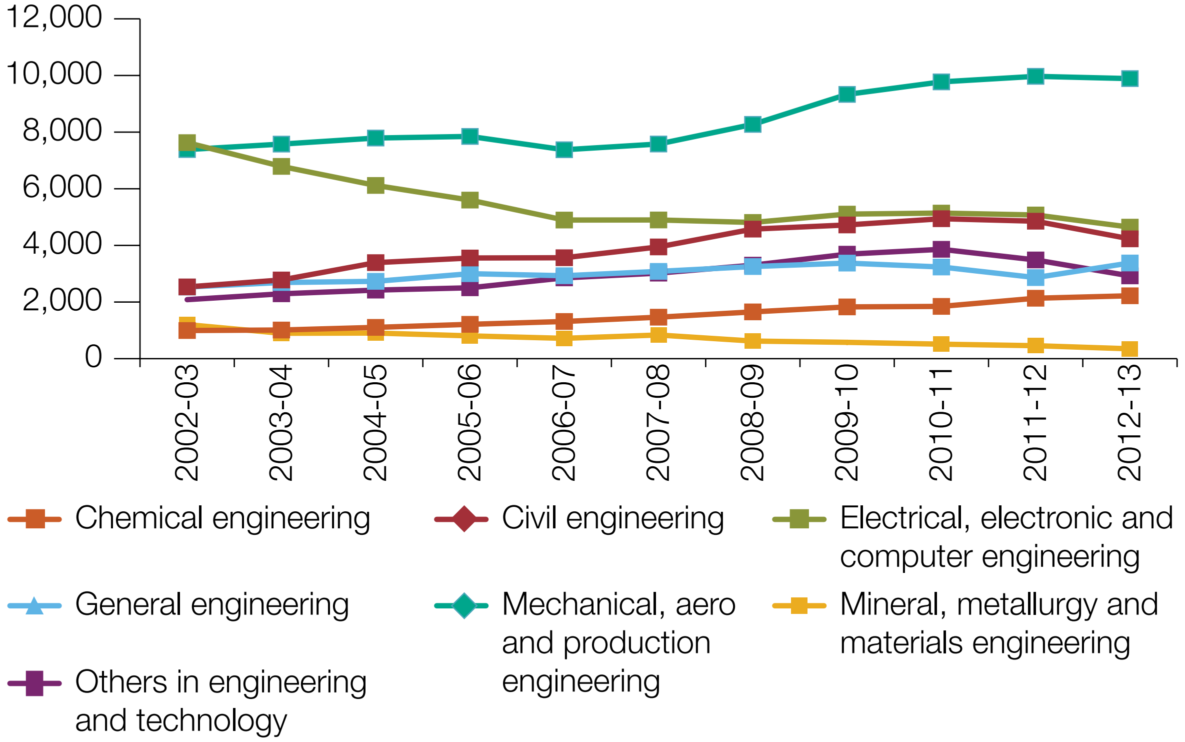
High-quality vocational education has the potential to support engineering skills development in both the short and long term. In the short term, the FE system can help deal with specific skills gaps, especially if flexible methods of funding can be found. Over the longer term, there is the potential through UTCs, apprenticeship reform, and the development of elite provision to create a high quality, aspirational pathway that can secure a robust pipeline of future engineers.

5 Higher Education

Introduction

Higher education remains a highly esteemed pathway into engineering. Over the last seven years, the number of acceptances into engineering degrees has increased by over 20% to 25,300 in 2012. Maths and physics entrants are also up, by 35% and 48% respectively.[32] However, there are signs of weaknesses in specific engineering disciplines, for example, electrical and electronic engineering, and manufacturing and production engineering, where there are falling applications and acceptances. There was also a significant decline in computer engineering after the dot-com bubble burst in 2000 even though there continues to be significant demand for computer engineering skills. The following chart shows the trends over the last decade in different areas of engineering.

UCAS acceptances in engineering and technology 2012[33]



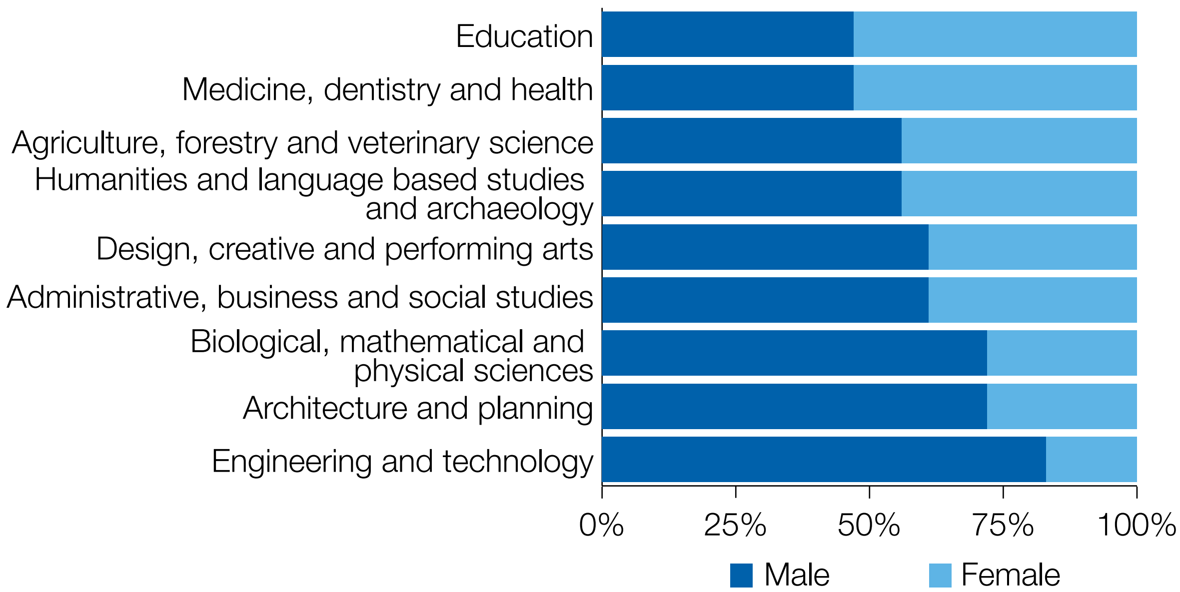
32 UCAS data, Applications (choices), acceptances and ratios by subject group.
33 HEFCE briefing on data about demand and supply in higher education subjects.

A recent Royal Academy of Engineering survey of the state of engineering education in the UK drew a mixed picture.[34] Engineering at Pre'92 universities demonstrated "security and strength", with strong demand manifested in increasing applications and UCAS tariffs high and generally rising. Yet, the number of acceptances remained steady, with 46 Pre'92 universities accepting around 14,900 engineering students via UCAS in 2012. In other words the supply of engineering places at Pre'92 universities has not expanded, despite clear demand from students.

Meanwhile engineering at Post'92 universities is less secure, with acceptances having fallen overall since 2010, even though many of these universities have accredited degree programmes. The average UCAS tariff is 150 points lower than in Pre'92 universities. A total of 63 Pre'92 institutions accepted 9,400 engineering students via UCAS in 2012. This means that programmes at Post'92 universities tend to be much smaller, recruiting an average of 150 students each year compared to 320 at Pre'92 universities.

There is a serious risk that, if we do not act now to secure the future viability of the HE talent pipeline for engineering, falling student numbers could lead to a new wave of skills shortages. First, the system is not adjusting to increased demand for engineering courses in acknowledged centres of excellence and there are also signs that engineering provision at some other institutions may be in decline. Second, there is a need to invest in the quality of the teaching infrastructure and for HE institutions to engage with employers to ensure that their provision is world class and in line with industry expectations. Third is the issue of the relatively small proportion of women in engineering at university departments, whether as students or staff (see chart). Finally, there is some evidence of unsatisfied demand by industry for doctoral level engineers.

Full-time academic staff by gender 2011/12[35]

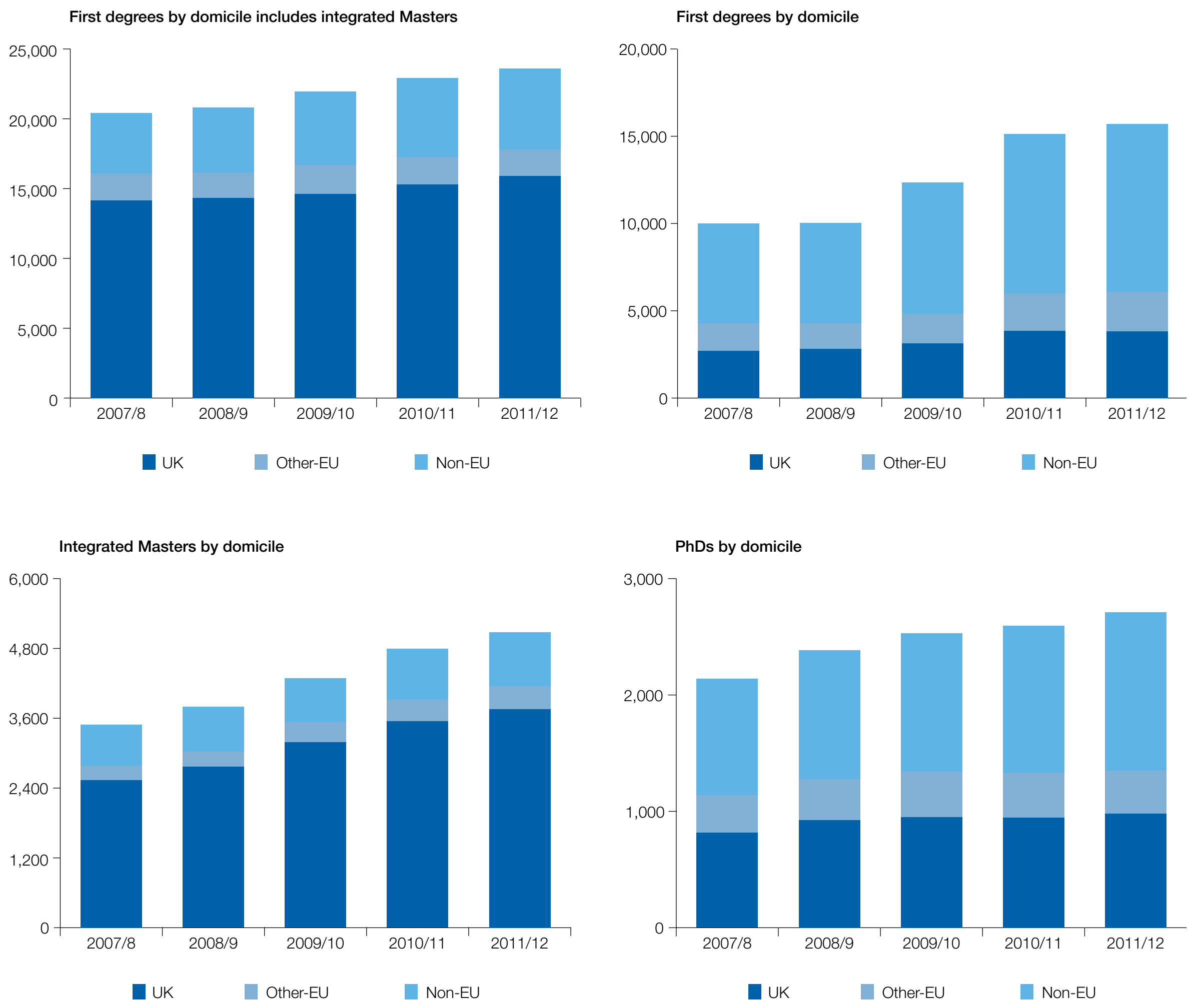


[34] Royal Academy of Engineering, Skills for the nation: engineering undergraduates in the UK 2013.

[35] HESA staff data.

For those taking an academic path into engineering, an accredited bachelors or masters-level degree provides the most straightforward route to Incorporated (IEng) or Chartered (CEng) Engineer status respectively. Many undergraduate engineering degrees are "integrated masters" degrees that lead to a masters-level qualification (MEng), meeting the CEng requirements. For those who graduate with a BEng or in a related field such as physical science, taught postgraduate degrees provide one important route for progressing to CEng status, as well as being a mechanism for conversion to engineering, and for acquiring specialist skills and knowledge. Enrolment of UK-domiciled students on taught masters programmes in engineering and technology has been flat since 2010/11 and the overall number of students taking postgraduate taught courses has started to fall after a number of years of growth.

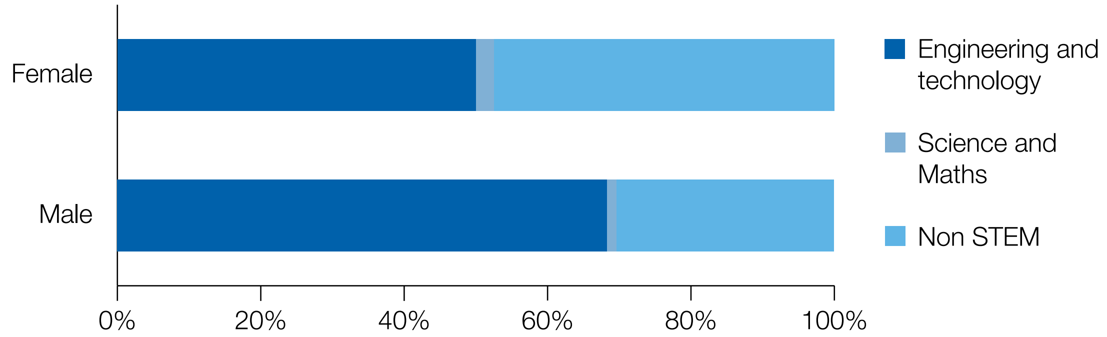
Engineering and technology degrees awarded by UK HE institutions by domicile[36]



[36] HESA student record.

Of course even if students graduate in engineering, in a flexible labour market, those with highly marketable skills have a range of employment options available to them, including engineering. There is significant leakage at the juncture between HE and employment: three years after graduation just under 70% of male engineering and technology graduates are working for employers in those fields. This in itself is a cause for concern – more worringly still, as illustrated in the following chart only half of their female counterparts take up employment in engineering and technology further widening the gender gap.

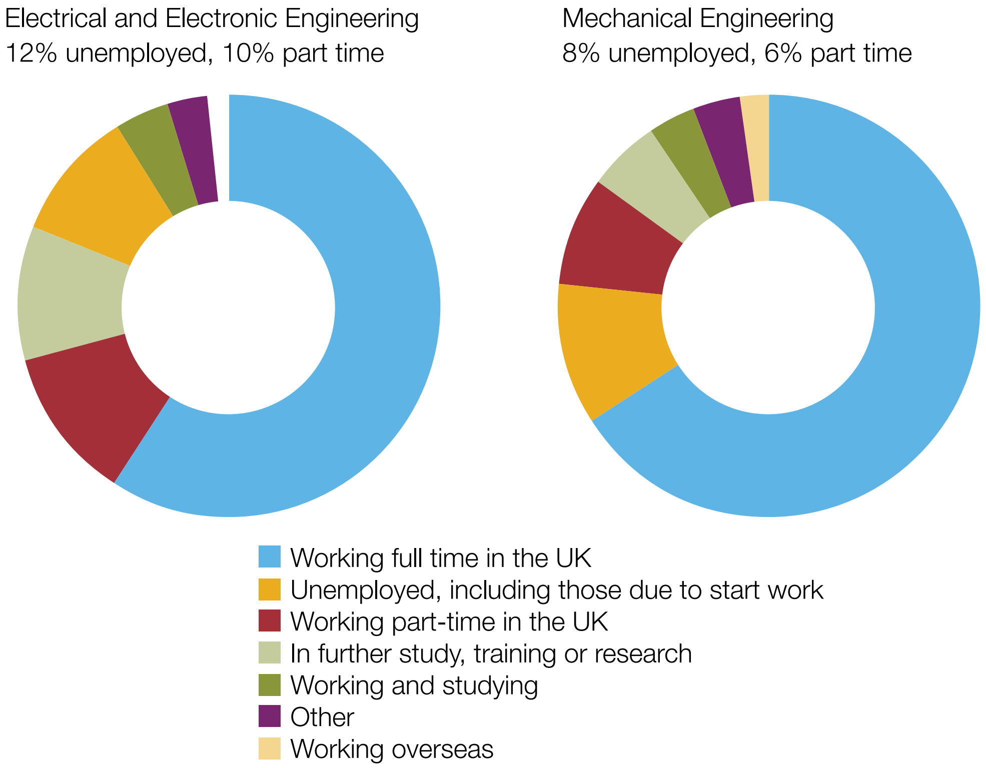
Destination (type of employer) of employed UK-domiciled graduates with first degrees in engineering and technology graduating in 2010/11[37]



In addition, and rather surprisingly, despite concern about shortages of engineering skills, significant numbers of engineering graduates are unemployed or only employed part-time following graduation. This varies by engineering discipline. For example, electrical and electronic engineering has a somewhat higher percentage of unemployed/part-time employed graduates than mechanical or civil engineering. This merits further examination by the profession and HE institutions and I welcome the work being undertaken by the Royal Academy of Engineering which is investigating the complex issues behind these troubling figures.

[37] HESA, Destinations of Leavers from Higher Education Institutions.

UK-domiciled first degree graduates, 6 months after graduation[38]



What we are doing?

Safeguarding and growing the supply of graduates

HEFCE has sought to protect the number of places in engineering (as well as chemistry, maths and physics). However, in an increasingly market-driven HE system, institutions focus delivery where there are optimal gains to ensure their financial sustainability and allow them to protect the interests of their students. High quality, research-led education is resource intensive and expensive. Escalating teaching costs and capped fee income combine to make it increasingly unsustainable for HE institutions to deliver engineering degrees for UK and EU students to the standard required to meet industry needs. Engineering teaching for many HE institutions is at best a 'break-even' activity, even accounting for the Band B teaching grant contribution (£1,500 per FTE in 2013/14) and the additional grant for high cost subjects.

Improving the quality of teaching

In order to improve the quality of teaching, it is vital to improve the quality of the STEM teaching environment in HE, which has suffered from a period of under-investment. Additional investment is needed to bring our engineering provision into line with

[38] HESA Destinations of Leavers from Higher Education Institutions.

industry standards and expectations. The UK's capital investment in HE lags competitor countries. The most recent OECD statistics show that the UK spent only 0.07% of GDP on HE capital in 2009, well below the OECD average: the US and Australia spend three times as much as a proportion of GDP.[39] Although the international competitiveness of leading UK HE institutions is strong, the one area in which they underperform is the quality of their learning spaces.[40]

Employer investment in Higher Education

The School of Engineering at the University of Lincoln has been developed in collaboration with Siemens. The School aims to produce graduates who are academically excellent and 'industry ready' in a purpose-built engineering centre with state-of-the-art R&D and teaching facilities.

Coventry University and Unipart are collaborating to build a £32 million Engineering and Manufacturing Institute. The project received £8 million from HEFCE's Catalyst Fund and Unipart is contributing £18 million towards the creation of the new facility with a further £6 million towards R&D and student scholarships, including support for the undergraduate and postgraduate programmes in manufacturing and advanced engineering and management.

Collaboration with engineering firms can leverage additional investment as well as ensuring that any capital investment from the Government is targeted on provision that is fit for purpose. Employer engagement is important because evidence suggests that engineering education does not always provide the skills and knowledge that employers require. For example, in a recent survey a quarter of engineering employers reported that they felt the content of engineering courses was not meeting their skills needs, principally because degrees do not adequately develop practical skills and/or lack specific technical content.[41] Engineering has a well-developed system of professional accreditation, which recognises those courses that provide their graduates with the skills and knowledge required to register as professional engineers.[42]

The proportion of female applicants to engineering undergraduate courses has remained low at approximately 15-16% over the last decade. We support the National Centre for Universities and Business' (NCUB) ambition to double the proportion of engineering degrees taken by women to 30% by 2030. The most important actions to achieve this are the measures to increase the number of young women leaving

39 OECD EAG 2012.

40 Russell Group, Staying on top: The challenge of sustaining world-class higher education in the UK, 2010.

41 Institution of Engineering and Technology 2013 Skills and Demand in Industry Survey. Some sectors were found to be more dissatisfied than others, for example, the electronics and electrical engineering sector.

42 Information on which courses are professionally accredited is available at the Engineering Council website (www.engc.org.uk/courses). This is linked directly with the Key Information Sets offered through the Unistats website.

school with the right academic qualifications and to tackle gender-biased perceptions of engineering. Government has sought to address the issues of access and retention in higher education by introducing a new framework for widening participation with increased responsibility on HE institutions.

Funding for postgraduate degrees

As noted above there has been a flattening of enrolments of UK students onto Masters courses in engineering and technology. One of the reasons for this, highlighted by the engineering community, is uncertainty and difficulty about funding for taught postgraduate courses which comes from a variety of sources, including an estimated £14 million provided by HEFCE. Fewer students are being supported by employers. Most UK-domiciled students studying for taught postgraduate courses in engineering and technology are self-funded: over the past 5 years the proportion of self-funded students has risen from 42% to 68%, while the proportion funded by industry or their employer has fallen from 17% to 12%.[43]

Whitworth Scholarships

Government and IMechE support the Whitworth Scholarships, bursaries for high calibre students to undertake engineering courses, including MEng and MSc courses. Candidates must have pursued a vocational route in an engineering discipline for at least two years after leaving full-time education and demonstrated that they have the qualities to succeed in industry. Whitworth Senior Scholarships offer enhanced awards for students pursuing postgraduate research.

Government does provide support for postgraduate students to fund their studies via Professional Career Development Loans. These loans provide up to £10,000 to finance study on vocational or professionally-focused courses approved by the Skills Funding Agency as leading to a trade, occupation or profession. The loans are offered through commercial banks and Government bears the risk of defaulted repayments. No interest is charged while the student is studying, repayments and interest (at 9.9%pa) begin one month after the course has ended. To date, take up of these loans has been low: it is not clear whether this reflects informed choice by students (who may be able to access loans on more favourable terms) or a lack of knowledge amongst students about the product.

[43] EPC calculation based on Higher Education Database for Institutions.

High-level skills, as developed during PhD training, are crucial elements in the development of high-tech industry and a knowledge economy:

> *"Economic growth can only be sustained if we and our suppliers can find the right people with the right skills. These people will help us develop the unique and innovative technologies that will enhance the appeal and desirability of our products and help us to compete successfully at a global level. The investment EPSRC makes in relevant research and postgraduate training in the UK plays a vital role in maintaining the supply of skilled people that will deliver the technologies of the future."*
>
> Dr Wolfgang Epple, Director Research and Technology, JaguarLandRover

Funding for PhD studies in engineering comes from a variety of sources, with EPSRC being a major funder, particularly of home-domiciled students. Around 1000 engineering PhD graduates emerge from EPSRC-funded schemes each year. The majority of PhD graduates (60-65%) leave HE to enter industry or other employment.

The EPSRC is investing £350 million in setting up a substantial number of Centres for Doctoral Training (CDTs) in universities, with a focus on the UK's most important sectors, key technologies, and most competitive future markets, including aerospace, pharmaceuticals, healthcare technologies, automotive, energy, digital economy and construction. A recent call for proposals for CDTs resulted in a very substantial response from the community, and significant levels of matching support from industry, giving a strong indication of high levels of demand from employers for PhD graduates in engineering and physical sciences.

Keeping engineers in engineering

Employers have a powerful role in helping secure engineers for engineering. Pilot work has demonstrated that there is significant appetite by STEM undergraduates to learn more about STEM career options during their studies. The challenge is for employers to engage more effectively across all HE institutions, by providing more students with industrial placements as well as better communication of the diverse range of opportunities in engineering. In addition, industrial placements are a key way for students to acquire relevant skills, as students themselves understand: 54% of engineering graduates believe that gaining industrial experience during their course would increase their chances of getting a job.[44]

[44] www.theengineer.co.uk/Journals/2013/08/02/k/o/w/Engineering-sector-student-survey-2013.pdf

What do we need to do?

In recent years, we have seen growth in the number of engineering graduates from our HE system. But there are risks for the future, both in terms of the continued supply, and in seeking to ensure that these skilled people are not tempted into other areas of the economy. As well as considering the flow out of university, the profession needs to look at the stock of potential engineers; such as converting those with related science backgrounds (such as physics) or reactivating those who are unemployed or have had a career break. There is substantial scope for the industry and the profession to make an impact. My recommendations are:

Government should review funding arrangements for engineering degree courses to ensure that it is financially sustainable for HE institutions to deliver high-quality engineering programmes.

Government should ensure that the £200 million teaching capital fund encourages diversity by seeking evidence of commitment (e.g. through Athena SWAN registration) as a prerequisite for receiving funding.

HE institutions should work with Government and commercial banks to ensure their students are aware of Professional Career Development Loans.

The engineering community should develop concerted engagement with university students, including work placements to raise the profile of engineering careers and ensure that students on every campus are aware of the full range of diverse opportunities with engineering employers, large and small.

Engineering employers should explore the potential for developing cooperative cross-sector schemes to support postgraduate students.

Government, through EPSRC, should seek further evidence of unsatisfied demand for engineers trained to doctoral level, and review arrangements for the support of PhD students in the light of their findings.

Conclusion

Higher education – undergraduate and graduate study – is the pinnacle of our engineering skills system, and has a strong international standing and reputation. To maintain and enhance this position, and the quality and capacity of the engineering HE system, future investment in facilities, and strong engagement by industry and the profession will be essential. In addition, the industry and profession need to focus on both the stock of 'potential' engineers in the workforce, and ensuring that those who have been inspired from a young age to become engineers do not fall to temptations from elsewhere in our economy. Whilst deployment of engineering skills in the wider economy brings benefits, our first priority should be to exploit those precious skills in engineering-related employment, where the need is greatest.

A call to action

Our country would benefit from having more engineers. It is a long-term necessity given the shape of technological progress and the demands of the global race. We need to ensure that there is a strong flow of talented men and women to meet the demands of our economy in 2050, and that means taking action that will not pay off immediately, but will deliver results over the next ten to fifteen years. The good news is that the building blocks are in place – inspirational activities, a strong focus on maths and science in school, more apprenticeships, UTCs and our continued strength in higher education all provide some comfort that we are heading in the right direction.

However, if we want to build on that, we need to take action in both the short and long term. We need to get the right messages to young people. We desperately need to ensure that girls have the opportunities to study STEM subjects and don't rule themselves out too early. We need higher quality, high status vocational pathways and we need to ensure that HE continues to deliver.

But we face some short-term pressures. Unlike other skills, engineering skills take time to acquire, but it is possible for people with similar core skills to become proficient, and industry and government should look at ways to make the most of the pool of potential engineers.

Finally, I want to emphasise that this is an agenda for all with an interest in engineering – businesses, professional bodies, and educational institutions – as well as Government. There have been dozens of Government reports, select committees and independent reviews into the future of engineering skills over the past 150 years. I would go further. It is time for concerted action by the profession, industry and Government, to achieve the goals for engineering which we all share.

List of consultees

Engineering Employers

Airbus
ARM Holdings
Arup
BAE Systems
Babcock International
BP
Dow
Dyson
EDF
Group Rhode
GSK
IBM
JaguarLandRover
JCB
JJ Churchill plc
Mott McDonald
National Grid
Rolls-Royce plc
Schlumberger plc
Siemens
Syngenta
WS Atkins

And members of the Royal Academy of Engineering Diversity Leadership Group

Professional Institutions and other Bodies

Career Academies UK
Confederation of British Industry
Chemical Industries Association
Cogent
Daphne Jackson Trust
e-skills UK (National Skills Academy for IT)

Energy and Utility Skills
Engineering Employers' Federation
Education for Engineering (E4E)
Engineering Council
Engineering Development Trust
Engineering Professors' Council
EngineeringUK
The Gatsby Charitable Foundation
Institution of Engineering and Technology
Institution of Mechanical Engineers
Institution of Civil Engineers
Institution of Chemical Engineers
Institute of Physics
National Centre for Business and Universities
National Skills Academy for Nuclear
Royal Academy of Engineering
Science Council
SEMTA
STEMNET
UK Commission for Education and Skills
Women's Engineering Society
Women in Science and Engineering

Universities

Universities UK
University of Birmingham
Oxford Brookes University
University of Sheffield
University of Southampton
University of Surrey

Picture credits: Young engineers featured on the front cover

1. Roma Agrawal – Roma is a structural engineer at engineering consultancy firm WSP Atkins. The picture depicts Roma overseeing the construction of the Shard, one of the world's most recognisable and iconic buildings which she helped to design using computer modelling. A large part of Roma's work is to present to and meet with clients, which often involves overseas travel. Credit: IET

2. Colleen Campbell, Gold medal winner in the WorldSkills UK National Aeronautical Engineering competition in 2010. The UK competed at WorldSkills, the world's largest international competition in London in 2011 and won medals in engineering competitions such as Mechanical Engineering Design – CAD, Welding, and Automobile Technology. Credit: WorldSkills UK

3. Jo Carris at the Olympics Aquatic centre. Jo is a civil engineer and works within the Sustainability Team for London 2012 specialising in energy and waste. She also provides technical advice and assurance on the development of sustainability strategies for the 2014 Brazil Wold Cup and 2016 Olympic and Paralympics games in Rio. Credit: Jo Carris/STEMNET.

4. An example of a working group including Yewande Akinola, an environmental services engineer at Arup and the IET's current Young women Engineer of the Year. Behind every great project is a team of engineers like Yewande who work with architects to turn concepts into a reality. Yewande has been recognised for her commitment to sustainability and innovation, especially around water supply technology. Credit: IET

5. Steven Burge, pictured at the WorldSkills 2012 Squad UK selection event, competing in the Refrigeration and Air Conditioning competition. Steven went on to compete as part of Team UK at WorldSkills Leipzig 2013. He won a Medallion for Excellence as he achieved the World Class standard in his skill. Credit: World Skills UK

6. Mairead Kelly is a Design Engineer at Dialog Semi-conductor; a challenging role which also allows her to be creative and useful to society. Design engineers apply the engineering design process to develop new products or processes with an emphasis on functional utility. In her current job, Mairead designs audio chips that allow music to be easily accessed, stored and shared on mobile phones and MP3 players. Credit: Mairead Kelly

Any enquiries regarding this publication can be emailed to us at: enquiries@bis.gsi.gov.uk

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