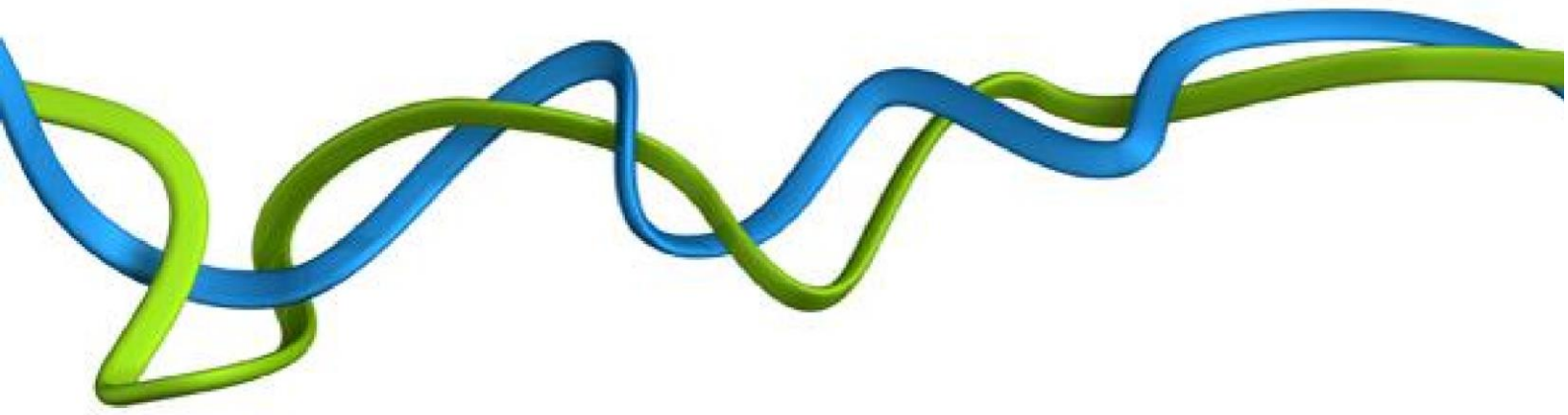
ROYAL ACADEMY OF ENGINEERING

Closing the STEM skills gap

A response to the House of Commons Science and Technology Committee inquiry into closing the STEM skills gap

January 2017



About the Royal Academy of Engineering

As the UK's national academy for engineering, we bring together the most successful and talented engineers for a shared purpose: to advance and promote excellence in engineering.

Royal Academy of Engineering Response to the Closing the STEM skills gap inquiry launched by the Science and Technology Committee.

The Royal Academy of Engineering welcomes the opportunity to contribute to the Science and Technology Committee's inquiry on closing the STEM skills gap. The Academy is deeply committed to ensuring young people have the best possible opportunity to study and pursue careers in engineering and that business and industry are able to secure people with the skills in engineering that they need to succeed in an increasingly competitive environment. As the UK's national academy for engineering, we bring together the most successful and talented engineers from across the engineering sectors for a shared purpose: to advance and promote excellence in engineering. The Academy's response has been informed by the expertise of its Fellowship, which represents the nation's best practising engineers, including leading academics, industrialists, researchers, innovators and entrepreneurs.

Summary

The Academy undertakes many activities in schools, colleges and universities to encourage more young people to become engineers, with support from government, industry and charitable donors. This activity includes: changing the perceptions of engineering, leading on diversity, equality and inclusion for the sector, improving the quality of teaching and learning across STEM subjects, providing professional development for engineers and influencing government policy to increase participation and attainment in STEM.

Our key messages are as follows:

- Engineering is essential for the future prosperity and economic growth of the UK, with engineering-related sectors contributing at least £280 billion in gross value added to the UK economy – 20% of the total. There is also a well-documented engineering skills demand, with 90% of businesses in engineering, science and hi-tech believing they will be looking to recruit more people with higher skills in the next 3-5 years. However, supply is currently unable to keep up with demand and recent trends suggest this shortage will continue into the future.

- Less than 10% of the UK's engineering workforce are women and only 6% are from minority ethnic backgrounds, therefore, widening participation in underrepresented groups is an essential part of addressing the engineering skills challenge.

- The Academy has identified seven key issues causing the engineering skills shortage. They are listed in the body of the submission. A systems approach to addressing all of these issues needs to be taken to ensure the supply of engineers for the future. The skills shortage will not be solved if only some of the challenges are addressed in isolation.

- The Academy contributes to addressing some of these key issues through activities that we deliver. These include:
    - The Engineering Talent Project (ETP)
    - Connecting STEM teachers
    - Regional support programmes in schools
    - Visiting Professors scheme
    - Engineering Leaders Scholarships
    - Higher Education Employer Diversity Pilot Project
    - Additional activities that support talent development

  More information is provided on these later in the submission.

- Numerous organisations have been working to encourage young people to pursue STEM subjects at school, college and university, and to improve the quality of

teaching and learning across STEM subjects. However, despite many years of intense activity, there has been limited growth in the number of young people taking up subjects leading to engineering careers.

- The sheer number and diversity of organisations involved in addressing the STEM skills gap has created a highly complex landscape that is confusing to schools, employers and other stakeholders and there is limited understanding of where or how the greatest impact can be achieved. In addition, the lack of consistent evaluation across providers means it is difficult to ascertain which interventions are having the most impact.

- The Academy undertakes independent external evaluations of all its activities, which aim to address the key issues identified above. Evaluations of the Academy's activities have demonstrated their effectiveness and the success of the targeted, bespoke support that we provide.

- However, due to the magnitude of the engineering skills challenge, the Academy is developing a major new national campaign to extend the reach of our impact and promote engineering to young people, their parents and influencers. The Engineering Talent Project (ETP) will re-position engineering in the public mind-set and is aimed at providing a long-term solution to the engineering skills challenge. An important strand of the ETP is the expansion of the Tomorrow's Engineers programme, delivered by EngineeringUK on behalf of the engineering profession. It is currently working to coordinate the activities of employers and other STEM providers, reduce duplication of effort and maximise the impact of activities in schools.

The STEM skills that are needed but in short supply: The engineering skills challenge

1. Engineering is essential for the future prosperity and economic growth of the UK, with engineering-related sectors contributing at least £280 billion in gross value added to the UK economy – 20% of the total[1]. Some 52% of engineering companies are currently recruiting engineers at technician level and above, with over half of those experiencing difficulties in recruiting the experienced engineers they need[2]. Demand for people with higher skills is expected to rise significantly, with 90%[3] of businesses in engineering, science and hi-tech expecting an increase in demand over the next 3-5 years[4].

2. However, the chronic failure to encourage enough young people to become engineers and skilled technicians is a serious threat to the UK's engineering competitiveness. An ageing workforce means that hundreds of thousands of technicians and engineering roles will need replacing over the next ten years. EngineeringUK have undertaken a detailed analysis of the skills demand and supply and have found that there is an annual shortfall of 29,000 people with level 3 skills and 40,000 with level 4+ skills[5]. Furthermore, following the result of the EU referendum, there is a risk that the profession is likely to encounter even greater challenges in recruiting sufficient engineers and technicians to meet the needs of industry[6].

3. A key challenge for the engineering profession is widening participation among underrepresented groups, both in the current engineering workforce and those young people studying subjects leading to engineering. Less than 10% of the UK's engineering workforce are women – the lowest number across the whole of Europe[7]. The statistics for engineers from minority ethnic backgrounds are also poor at around 6%, despite the fact that those from ethnic minorities account for 14.1% of the England and Wales population (Census 2011) and around 20% of the higher education cohort

Factors causing the engineering skills challenge

1. The Academy has identified seven key issues that are hampering supply of future engineering skills. It is essential that all seven issues are properly addressed to tackle the engineering skills challenge. The seven issues are summarised below:

- Lack of understanding and poor perceptions of, and attitudes towards, engineering among young people and their influencers, including parents.
- Shortages of specialist teachers in all the school subjects that lead to further engineering study and limited understanding of engineering among teachers.

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[1] *Engineering a future outside the EU: securing the best outcome for the UK*, Royal Academy of Engineering and Engineering the Future, 2016
http://www.raeng.org.uk/publications/reports/engineering-a-future-outside-the-eu

[2] *Skills and Demand in Industry Survey*, Institution of Engineering and Technology (IET), 2016, p12-13
http://www.theiet.org/factfiles/education/skills2016-page.cfm

[3] Businesses reporting increased demand minus those reporting decreased demand

[4] *The right combination: CBI/Pearson education and skills survey 2016,* CBI, 2016
http://www.cbi.org.uk/cbi-prod/assets/File/pdf/cbi-education-and-skills-survey2016.pdf

[5] *Engineering UK 2016: The state of engineering*, EngineeringUK, 2016
http://www.engineeringuk.com/_resources/documents/EngineeringUK-Report-2016-Full-Report_live.pdf

[6] *Engineering a future outside the EU: securing the best outcome for the UK*, Royal Academy of Engineering, 2016
http://www.raeng.org.uk/publications/reports/engineering-a-future-outside-the-eu

[7] Women Engineers Society http://www.wes.org.uk/statistics

- Under-representation of specific groups, particularly women and minority ethnic groups.
- Poor careers advice and guidance in schools, particularly with regards to engineering careers.
- Issues around qualifications, assessment and accountability measures driving behaviours among students, teachers and school leaders. In particular, narrowing of the curriculum at age 14 and 16 forces students to make subject choices that affect the rest of their lives without knowledge of the impact of their decisions.
- A lack of parity of esteem between academic and vocational pathways including apprenticeships.
- The high cost of delivering up-to-date engineering provision in further and higher education establishments.

2. Further details of these seven issues can be found in **Annex 1**.

Key activities undertaken by the Royal Academy of Engineering to address the engineering skills challenge

3. The Academy is deeply committed to ensuring young people have the best possible opportunity to study and pursue careers in engineering. As the UK's national academy we provide leadership, guidance and practical support across all phases of education. The Academy undertakes many activities in schools, colleges and universities to encourage more young people to become engineers, with support from government, industry and charitable donors. This activity includes: changing the perceptions of engineering, improving the quality of teaching and learning across STEM subjects, providing professional development for teachers and engineers and influencing government policy to increase participation and attainment in STEM.

4. The Academy has also been appointed by government to lead on diversity, equality and inclusion for the engineering sector. The Academy's diversity and inclusion programme covers all aspects of diversity including gender, ethnicity, disability, sexual orientation and social disadvantage and has two main strands. The first (Diversity Leadership Group) is a senior industrial leaders group working together to drive improvements in workplace cultures and practices. The second (Concordat group) brings the professional engineering institutions together to share good practice around increasing the membership and registration of a more diverse set of engineers. Both groups have built positive momentum, with numerous outputs for industry and the profession[8].

5. The Academy ensures it undertakes activities that align with our core strengths. For example, the Academy has found convening networks a very powerful way of encouraging talent development through sharing best practice, creating a supportive environment and identifying, nurturing and celebrating engineering talent. Furthermore, the Academy helps early career engineers and potential future engineers benefit from the experience of those at the pinnacle of the profession, often through mechanisms such as, masterclasses and mentorship. We also promote role models that showcase the enormous diversity of engineers and engineering. The current activities of the Academy are detailed below:

The Engineering Talent Project

6. At the request of a consortium of national UK engineering companies, the Academy is currently developing a national campaign to reposition engineering in the public mind-set: The Engineering Talent Project (ETP), a national campaign, due to be launched in September 2017, aims to change perceptions of engineering among young people, their influencers and the wider public and highlight the breadth of exciting career opportunities available.

[8] http://www.raeng.org.uk/policy/diversity-in-engineering

7. There is still a longstanding and ongoing concern among the engineering community that many people perceive engineering as manual and of low status – a set of occupations more readily associated with repair. Key influencers of young people have little understanding of engineering, with only 24% of parents and 44% of teachers acknowledging they know what people working in engineering do[9].

8. Public perceptions of, and attitudes towards, engineering need to be fundamentally changed to address skill shortfalls and meet increasing demand for engineers. Efforts to encourage young people into STEM subjects have resulted in a slowly increasing participation, but the scale of change required to address the forecast shortages is significant and long term. Outdated views of engineering are seen by many to be a key part of the problem.

9. The Academy is working with our partner organisation EngineeringUK to deliver the project which has four mutually reinforcing strands:

- A high-profile national communications campaign to raise awareness, change perceptions and promote the opportunities available.
- A national schools engagement programme – building coverage from 70,000 school children pa to 1.1 million pa over five years. The Tomorrow's Engineers programme brings a strategic approach to schools engagement and aims to create a national network of employers to improve coordination of activities in schools.
- A programme of public affairs and policy activity with industry partners to remove barriers, provide incentives and accelerate structural change.
- A workplace cultures programme to improve working practices across engineering employers to ensure industry is genuinely attractive to a diverse future workforce.

10. The communications campaign will provide the first large-scale opportunity to positively change the way engineering is promoted to the public. However, is it the combination of all four strands which will strengthen the outcomes of the project and the likelihood of effectiveness for the longer term.

11. The Academy is also collaborating with government on the planned 2018 'Year of Engineering Celebration' and will coordinate the Engineering Talent Project with the 'Year'.

Higher Education Employer Diversity Pilot Project

12. This project proactively brings female and black and minority ethnic (BME) engineering undergraduates, and recent graduates, to the attention of engineering employers, with the aim of increasing the flow of engineering graduates into engineering employment.

13. A recent Academy report, *Employment outcomes of engineering graduates: key factors and diversity characteristics*[10], found stark differences in employment outcomes between engineering graduates of white and minority ethnic origin – with a 20 percentage point difference between the proportion of white engineering graduates entering full-time employment (71%) and their BME counter parts (51%) after 6 months. Black engineering graduates had the lowest proportion in full time work at 46%.

14. This report also found that obtaining a 2:2 or below and studying at a post-92 university were key factors associated with unemployment of engineering graduates,

[9] *Engineers and Engineering Brand Monitor 2015,* IFF Research, 2015
http://www.engineeringuk.com/_resources/documents/Sep-2015-Engineers-and-Engineering-Brand-Monitor-2015-1.pdf

[10] *Employment outcomes of engineering graduates: key factors and diversity characteristics*, Royal Academy of Engineering, 2016
http://www.raeng.org.uk/publications/reports/employment-outcomes-of-engineering-graduates-key-f

and this was particularly evident in recruitment into engineering occupations. This is supported by *Professor John Perkins' Review of Engineering Skills*[11] which calls on engineering employers to widen the reach of their graduate recruitment to take in a wider range of universities.

15. These factors underpin the business case for taking a proactive approach to encouraging increased engagement between engineering employers and BME and female engineering undergraduates.

16. The project was initiated in June 2014 and the pilot will run for another two years with a focus on ensuring it delivers maximum impact and leaves a lasting legacy for individual companies and the profession at large. Currently, nearly 900 students have been attracted to the scheme and 297 have been selected. The project has cost around £150,000 and has been funded by the Academy through its core grant received from BEIS.

17. The project has achieved a high level of diversity in its participants: 31% of participants are women; 96% of participants are of black and minority ethnic (BME) origin; and 72% of participants are from post-92 universities. Furthermore, the project has benefited the employment prospects of the participants: 68.9% of participants chose engineering as their 1st choice destination; 75% of participants had an increased understanding of engineering career paths; and 62.3% of participants had an increased understanding of engineering recruitment processes.

Schools: Connecting STEM teachers programme

18. The Connecting STEM Teachers (CST) programme launched in September 2011 with the aim of developing a national network to inspire and support science, technology and mathematics teachers to ensure they have the knowledge and confidence to engage a greater number and wider spectrum of school students with 'STEM' in a holistic way.

19. The programme has been based on a cascade model of training with regional teacher coordinators (TCs) attending CPD sessions developed at the Academy and in turn disseminating their learning to teachers in their regions through network meetings. TCs also disseminate high-quality STEM teaching and learning resources developed by the Academy along with associated training and build local STEM connections across schools. There are around 45 TCs operating across the whole of the UK, supporting up to 750 schools. While the focus is on teachers, we estimate that, to date, some 70,000 students have benefitted from the programme.

20. The overall objectives of the programme are to promote a passion for 'STEM' amongst teachers, to develop a greater awareness of engineering, to widen teachers' knowledge and experience of engineering and to enable teachers to gain skills in teaching STEM in a holistic way. We believe that this targeting of teachers is an effective and sustainable approach that complements direct engagement with students.

21. The project costs around £500,000 per year. Funding is generously provided by Royal Dutch Shell, The Helsington Foundation, Petrofac Ltd and Boeing UK.

22. External evaluations have shown that the programme has provided regular opportunities for STEM teachers to share good practice and break down subject silos - particularly important as many teachers are increasingly receiving fewer opportunities to develop pedagogy through collaboration with colleagues. In addition, teachers' confidence in teaching STEM has increased as well as their knowledge of

[11] *Professor John Perkins' Review of Engineering Skills,* Department for Business Innovation & Skills, 2013 http://www.raeng.org.uk/publications/other/perkins-review-of-engineering-skills

STEM careers, use of real world applications in lessons and engagement with employers. The programme has also achieved a high level of gender diversity - the gender split is 54% males to 46% females among the teachers engaged. A major quantitative evaluation is currently underway.

Schools: Regional support programmes

23. The Academy's regional support programmes deliver long-term STEM engagement and support in areas of high socio-economic disadvantage and demonstrate the importance of long-term, sustained intervention from primary through to post-16. The projects enrich schools' STEM curricula and build links between schools and local employers to improve STEM education in the local area.

24. In 2005, the Academy launched the first of these projects in South London. Some ten years on, we have worked in five local areas across the UK. The projects in Barrow, Stoke and Lowestoft, launched in 2008, 2013 and 2015 respectively, are part of the Academy's ongoing efforts to encourage greater numbers of young people from a diverse range of backgrounds to become engineers and technicians. Young people are provided with opportunities to take part in authentic engineering projects.

25. The current Barrow, Stoke and Lowestoft projects have involved 32 primary schools, 15 secondary schools and 6 post-16 providers and have actively worked with 25 local engineering employers. The Academy established the Furness Education Skills Partnership (FESP) in 2009 to complement the Barrow Engineering Project (BEP) by creating a valuable forum for teachers and local STEM employers to strengthen links between employers and schools.

26. The programme costs around £60-70,000 for each regional programme per year and is funded by industry and charitable trusts. This is gradually reduced to around £25,000 per year. Both BEP and FESP are now largely self-sustaining with local industry and employers providing the majority of financial support to schools.

27. An independent evaluation has demonstrated the impact of the regional support programmes. The programmes have provided over 105,000 STEM learning opportunities for local students and promoted greater student enthusiasm and engagement with STEM. There have been significant impacts in STEM participation and attainment and in the potential future engineering skills supply in local areas. The programmes have also improved the attitudes and confidence of teachers. Furthermore, the programmes have achieved a high level of gender diversity, with female participation rates of 48%.

28. As demonstrated by **figure 1**, since the inception of the BEP in 2008 participation in triple science (individual physics, chemistry, biology) at GCSE in schools engaged in the BEP is now significantly higher than the national average. Despite being one of the most deprived areas of the UK, the results show that participation in triple science in Barrow has outpaced that of the national average across England against baseline data in 2007, the year before the BEP started.

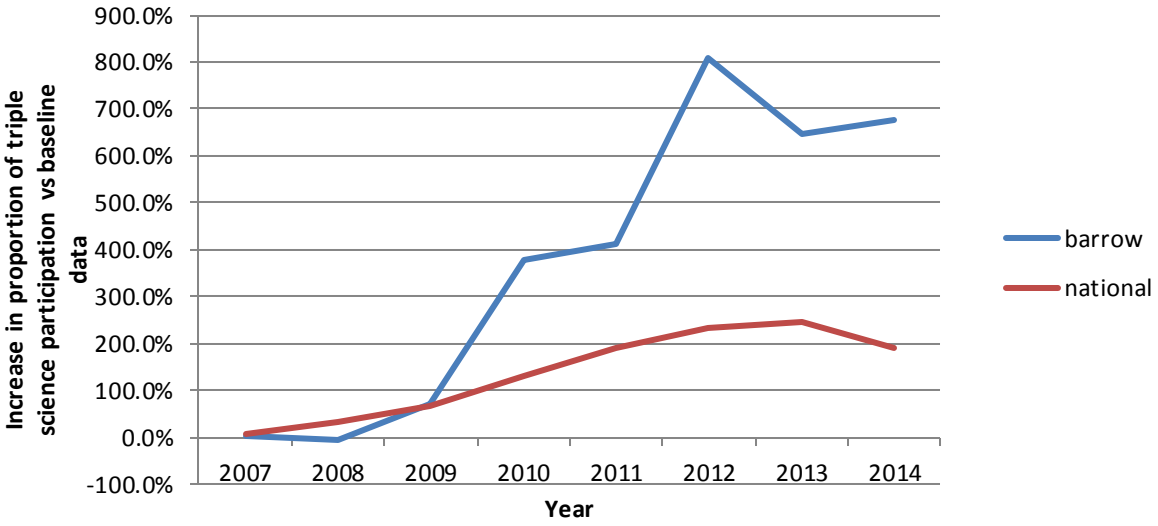

Figure 1: Increases in triple science participation against 2007 baseline data

29. In addition to GCSE results, Barrow has also significantly increased its AS level participation and attainment in physics and mathematics. Local FE colleges have also reported substantial increases in enrolment to engineering courses.

30. This highlights the value of the work the Academy has undertaken to create systemic educational change in underserved communities. This work has been successful due to the use of long-term, deep intervention involving primary and secondary schools and the FE sector to create a coherent programme which develops an engineering ethos in participating schools.

Higher education: Visiting Professors scheme

31. The Academy's Visiting Professors (VPs) scheme places senior industry professionals in Higher Education Institutions to teach, mentor and contribute to undergraduate projects, curriculum design and the strategic development of engineering faculty. This exposes students to real-life engineering, improves the employability and skills of UK engineering graduates and encourages links between industry and academia, thus supporting the findings of Sir William Wakeham FREng's recent *Review of STEM Degree Provision and Graduate Employability*[12], which highlighted the importance of both work-ready skills in graduates and employer engagement to better align the supply and demand for STEM skills.

32. In the VP scheme, host universities can receive up to £10,000 per year over three years to support an Academy Visiting Professorship. The scheme costs around £750,000 per year which is predominantly funded by the Academy through its core grant from the Department for Business, Energy and Industrial Strategy (BEIS). The scheme has been running for almost 30 years and has supported over 250 VPs, with over 20 new appointments each year.

33. An external evaluation demonstrating the impact and effectiveness of the VPs scheme was undertaken in 2014. This evaluation found that 75% of VPs felt their activities had a large or moderate impact on the quality of students' employability skills. Furthermore, nearly 70% of VPs felt they had a positive impact on students' engagement with the engineering profession, for example, via industrial placements and over 50% felt they had a positive impact on knowledge transfer activity between

[12] *Wakeham Review of STEM Degree Provision and Graduate Employability*, 2016 https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/518582/ind-16-6-wakeham-review-stem-graduate-employability.pdf

industry and host institutions. In addition, over 40% of VPs contributed to the development of new undergraduate teaching methods, such as, multi-disciplinary, real world projects.

Engineering Leaders Scholarships (ELS)

34. The Engineering Leaders Scholarships (ELS) scheme[13] is the Academy's flagship undergraduate education support programme for engineering students[14] at UK universities. The ELS scheme recognises engineering undergraduates in UK universities who demonstrate leadership potential and the ability to act as role models for future engineers. The aim is to help the students to acquire the skills to reach their potential and move into engineering leadership positions soon after graduating.

35. Benefits for scholars:

- Scholars receive £5,000 over three years to undertake an accelerated personal development programme (PDP)
- Mentoring opportunities through ELS Alumni, Sainsbury Management Fellows and Academy Fellows
- A training and networking weekend every year

36. Over the last 21 years the scheme has supported over 600 ambitious and inspiring engineering undergraduates who have the potential to become UK engineering industry leaders and act as role models for future engineers.

37. The programme is principally funded by the Academy through its core grant from BEIS. In 2016 £224,000 of BEIS funding and £80,000 of restricted funds were spent on the programme. This covered the participants' scholarships and training and networking events.

38. An external examination of the scheme demonstrated the benefits of the programme, particularly with regards to improving the retention of undergraduates in engineering. A survey, conducted with ELS Alumni, found that for 57% of respondents the programme was regarded as having influenced their career choice – with 73% entering employment in engineering businesses immediately after graduating. 77% of the survey respondents regarded the programme as having had a positive impact on the development of their professional/managements skills and 60% believed that the programme had had an impact on their career progression. Compared to the engineering profession, there is a high level of diversity in scholars in terms of gender – 66% of scholars were male and 34% female in 2016.

Additional activities that support talent development

- The Academy's Queen Elizabeth Prize for Engineering (QEP) is an international, £1 million engineering prize that rewards and celebrates the engineers responsible for a ground-breaking innovation that has been of global benefit to humanity. The objective of the QEP is to raise the public profile of engineering and to inspire young people to become engineers[15].

- The *Engineering a Better World* conference was a global conference hosted by the Academy in September 2016[16]. By demonstrating the incredible contribution

[13] For further details see: http://www.raeng.org.uk/grants-and-prizes/schemes-for-students/engineering-leaders-scholarship

[14] Applicants must be registered on an UK University undergraduate engineering degree course in the second year of a three or four-year course OR in the third year of a five-year course

[15] http://www.raeng.org.uk/grants-and-prizes/prizes-and-medals/other-awards/queen-elizabeth-prize-for-engineering

[16] http://www.raeng.org.uk/policy/international-policy-and-development/engineering-a-better-world-caets-2016

engineering makes in tackling some of the world's biggest problems, for example through the *Because Engineering* video[17], the conference aimed to attract the skills required by the profession.

- The Academy's Enterprise Hub harnesses the expertise, insight and networks of Academy Fellows, who include some of the UK's most successful entrepreneurs and business leaders, to support the country's most promising engineering entrepreneurs and support skills development in SMEs[18].

- The Academy's Research Fellowships are designed to promote excellence in engineering. They provide support for high-quality engineers and help to establish future leaders in research by making engineering research careers more attractive to the most talented researchers[19].

- The Academy's Ingenious scheme is an awards scheme for projects that engage the public with engineers and engineering. The programme aims including inspiring creative public engagement with engineering and raise awareness of the diversity, nature and impact of engineering[20].

The STEM Education Landscape

39. There are currently over 600 organisations involved in trying to address the UK's engineering skills challenge[21]. Many of these organisations undertake a range of activity; from direct interactions with school students and teacher continual professional development programmes to providing policy advice and guidance to government and other agencies. This has created a highly complex landscape, resulting in inefficiencies and, despite many years of intense activity, has led to limited progress in increasing the number of young people taking up subjects leading to engineering careers (**see Annex 2**).

40. Another key issue is the lack of consistent evaluation across providers – and in many cases, of any evaluation at all. The Academy has concerns over the effectiveness of 'single activity' interventions, such as careers talks and presentations compared with longer-term, sustained interventions, in terms of increasing attainment and progression to STEM education study in post-16 education.

41. The Academy undertakes independent external evaluations of all its activities, which aim to address the key issues identified above. The Academy also works to coordinate the activities of various providers through the Tomorrow's Engineers programme and is intending to expand this programme as part of the ETP.

Conclusions

42. The Academy strives to harness the expertise, energy and capacity of the profession to provide strategic direction for engineering and collaborate on solutions to the engineering skills challenge. Evaluations of the Academy's activities have demonstrated their effectiveness in addressing many of the issues that are

[17] http://www.raeng.org.uk/policy/international-policy-and-development/engineering-a-better-world-caets-2016/videos/because-engineering
[18] https://enterprisehub.raeng.org.uk/about/
[19] http://www.raeng.org.uk/grants-and-prizes/support-for-research/raeng-research-fellowship
[20] http://www.raeng.org.uk/grants-and-prizes/ingenious-grant
[21] *The UK STEM Education Landscape* report, Royal Academy of Engineering and Lloyd's Register Foundation, 2016 http://www.raeng.org.uk/publications/reports/uk-stem-education-landscape

preventing increasing numbers of young people taking up subjects leading to engineering careers.

43. Due to the magnitude of the engineering skills challenge, the ETP provides an important opportunity to extend the reach of the Academy's impact to a national scale and provide a long-term solution. However, this requires the engineering community to work together to achieve a major cultural shift in attitudes towards engineering.

44. An important strand of the ETP is the expansion of the Tomorrow's Engineers programme. It is intended that this should improve coordination, reduce duplication of effort and ensure that as wide a range of students as possible benefit from appropriate support.

45. The key areas identified by the Academy requiring further activity from the engineering/STEM community to address the engineering skills challenge are:
    - Improving the understanding of, and attitudes towards engineering among young people, their influencers and the public.
    - Coordination of enrichment activities to reduce duplication of effort and reach schools that are currently underserved.
    - Increasing recruitment of specialist STEM teachers and improving support for teachers of STEM subjects.
    - Widening access to under-represented groups.
    - Provision of more specific careers information on the routes to engineering careers in different sectors, and further advice and guidance on work experience, industry placements and application processes in engineering.
    - Improving teaching and learning in the FE sector and promoting practical, technical and vocational pathways to engineering.
    - Development of innovative teaching and increasing employer engagement methods in higher education.

    Unless all these areas are addressed, there is likely to be limited success in increasing the number of young people following engineering career paths.

ANNEX 1:

Factors causing the engineering skills challenge

1. From the age of five, children in the UK enter the formal education system and progress through a series of stages and transition points. At each of these main transition points, many young people either do not attain sufficiently high grades to be able to pursue further study towards engineering or they make subject choices that do not enable them to easily progress with engineering as a future career. **Figure A1** illustrates the scale of the challenge.

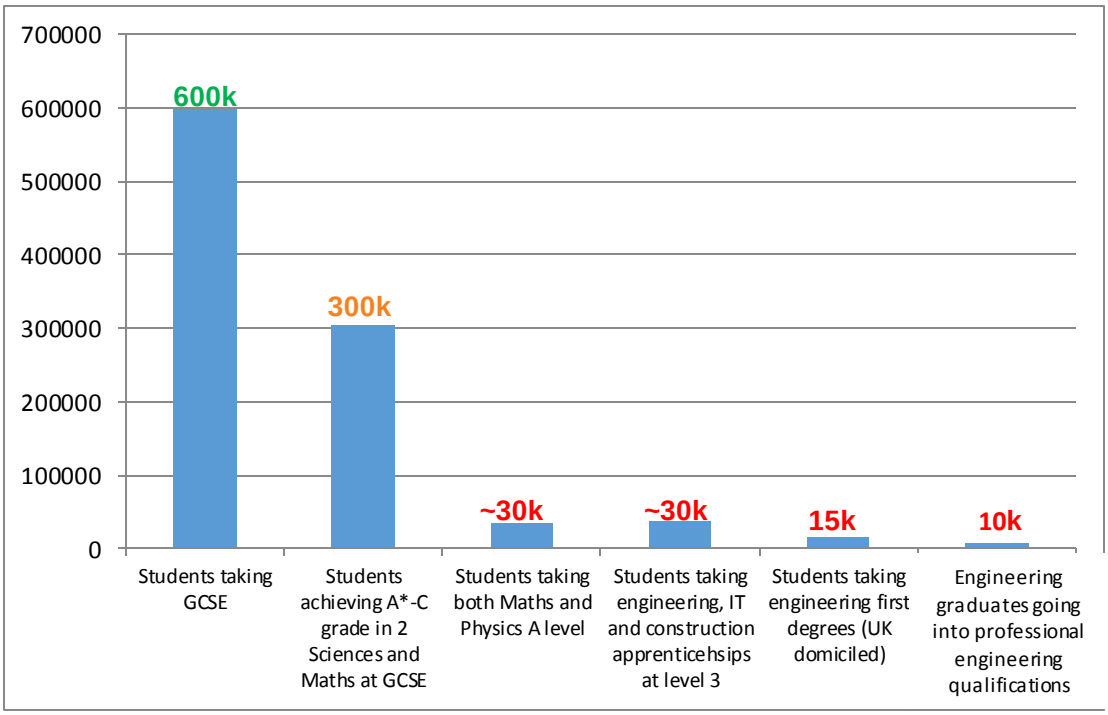

Figure A1: Key transition points for young people across various stages of UK education towards engineering[22]

2. The issues that are preventing increasing numbers of young people taking up subjects leading to engineering careers are varied and numerous. The Academy has grouped these issues into seven distinct areas and unless all are addressed there is likely to be limited success in increasing the number of young people following engineering career paths. They are:

3. <u>Perceptions of young people, their parents/carers and other influencers, and attitudes towards engineering.</u>
   Academy analysis has shown that young people, their influencers, parents, extended families, peers, teachers and the wider public have a general lack of understanding of engineering careers. The research shows that with appropriate information on the types of activity and the breadth of opportunities available through engineering, people can become positively disposed to careers in the sector.

4. <u>Teachers and teaching.</u>
   Across the UK there are shortages of specialist teachers in all the school subjects that lead to further engineering study; specifically, maths, physics, computing and

[22] Taken from: *The UK STEM Education Landscape*, Royal Academy of Engineering and Lloyd's Register Foundation, 2016 http://www.raeng.org.uk/publications/reports/uk-stem-education-landscape
Data from: *Engineering UK 2015: The State of Engineering* report, EngineeringUK, 2015
http://www.engineeringuk.com/EngineeringUK2015/EngUK_Report_2015_Interactive.pdf

design and technology. Of those specialist and non-specialist teachers who do teach the subjects, often their limited understanding of engineering means they are not able to readily provide practical, real-life contexts for what may be otherwise apparently abstract concepts to students in the classroom. There is therefore a need for teachers to enhance their subject knowledge with professional development opportunities to embed engineering examples into their teaching.

5. Under-representation of specific groups.
While this may actually be a consequence of the other causes, the issue of under-representation of women, minority ethnic groups and others is of such significance to the engineering skills challenge that that it warrants recognition in its own right. The issue of under-representation is again complex with different groups affected by different factors such as identity, perceptions and attitudes, attainment and progression and teaching. For example, the Engineers and Engineering Brand Monitor 2015 found that even by age 7-11 there were gender differences - with 52% of males having a positive perception of engineering compared to just 29% of females[23].

6. Careers advice and guidance, curriculum enhancement and employer engagement.
The provision of careers guidance in schools across the UK is patchy. In England, there is a minimal duty on schools to provide careers advice and guidance. In the last year, 58% of teachers of pupils aged 14-19 reported that they had been asked for careers advice regarding engineering. However, only 37% of teachers and 15% of parents felt confident giving advice on engineer careers[24]. Programmes such as Tomorrow's Engineers, delivered by EngineeringUK and supported by the Academy, are working to increase employer engagement activities in schools, however, currently schools engage with this approach on an ad-hoc basis.

7. Curricula, qualifications, assessment and accountability measures.
In England, N. Ireland and Wales it has been argued that the curriculum narrows too quickly from a broad set of GCSEs to only three or four A levels. This results in students having to make subject choices that affect the rest of their lives at age 14, before they fully understand the implications of the decision and before they are fully informed about future opportunities. In addition, qualifications, assessment and accountability measures may drive perverse behaviours among students, teachers and school leaders. For example, for post-16 progression in sciences, maths and engineering, schools and other providers now regularly require GCSE grades of A* or A with some schools accepting B grade for progression[25].

8. Pathways to progression.
There are multiple pathways to progression in engineering, including the academic route, the vocational route, which provides a more practical and applied learning approach, and apprenticeships. However, 44% of teachers would recommend an academic route into an engineering career, whereas only 15% would recommend a vocational route[26]. Therefore, despite many students entering engineering through vocational routes, there is still a strong perception that A levels, specifically in maths and physics, are pre-requisites for engineering degree study.

9. Facilities and capacity in further education (FE) and higher education (HE).

[23] *Engineers and Engineering Brand Monitor 2015,* IFF Research, 2015 http://www.engineeringuk.com/_resources/documents/Sep-2015-Engineers-and-Engineering-Brand-Monitor-2015-1.pdf
[24] *Engineers and Engineering Brand Monitor 2015,* IFF Research, 2015 http://www.engineeringuk.com/_resources/documents/Sep-2015-Engineers-and-Engineering-Brand-Monitor-2015-1.pdf
[25] *The UK STEM Education Landscape*, Royal Academy of Engineering and Lloyd's Register Foundation, 2016 http://www.raeng.org.uk/publications/reports/uk-stem-education-landscape
[26] *Engineers and Engineering Brand Monitor 2015,* IFF Research, 2015 http://www.engineeringuk.com/_resources/documents/Sep-2015-Engineers-and-Engineering-Brand-Monitor-2015-1.pdf

Engineering is a high cost subject to deliver in further and higher education establishments, requiring replenishment of consumables, specialist equipment, software, hardware, laboratories and other infrastructure. There is a need for colleges and universities to secure sufficient funding to ensure up-to-date engineering teaching is provided.

ANNEX 2:

The STEM Education Landscape

The Academy, with support from the Lloyd's Register Foundation, produced *The UK STEM Education Landscape* report[27] in 2015 to provide stakeholders with a detailed picture of the current issues in STEM education and an analysis of the organisations that are contributing to addressing the challenge of future STEM skills. The report highlighted over 600 organisations; professional bodies, charitable trusts, 3rd sector providers and others working in STEM education. This figure excluded individual employers and HE institutions, which would put the figure well in excess of a thousand organisations. An illustration of the type of bodies involved is shown in **figure A2.**

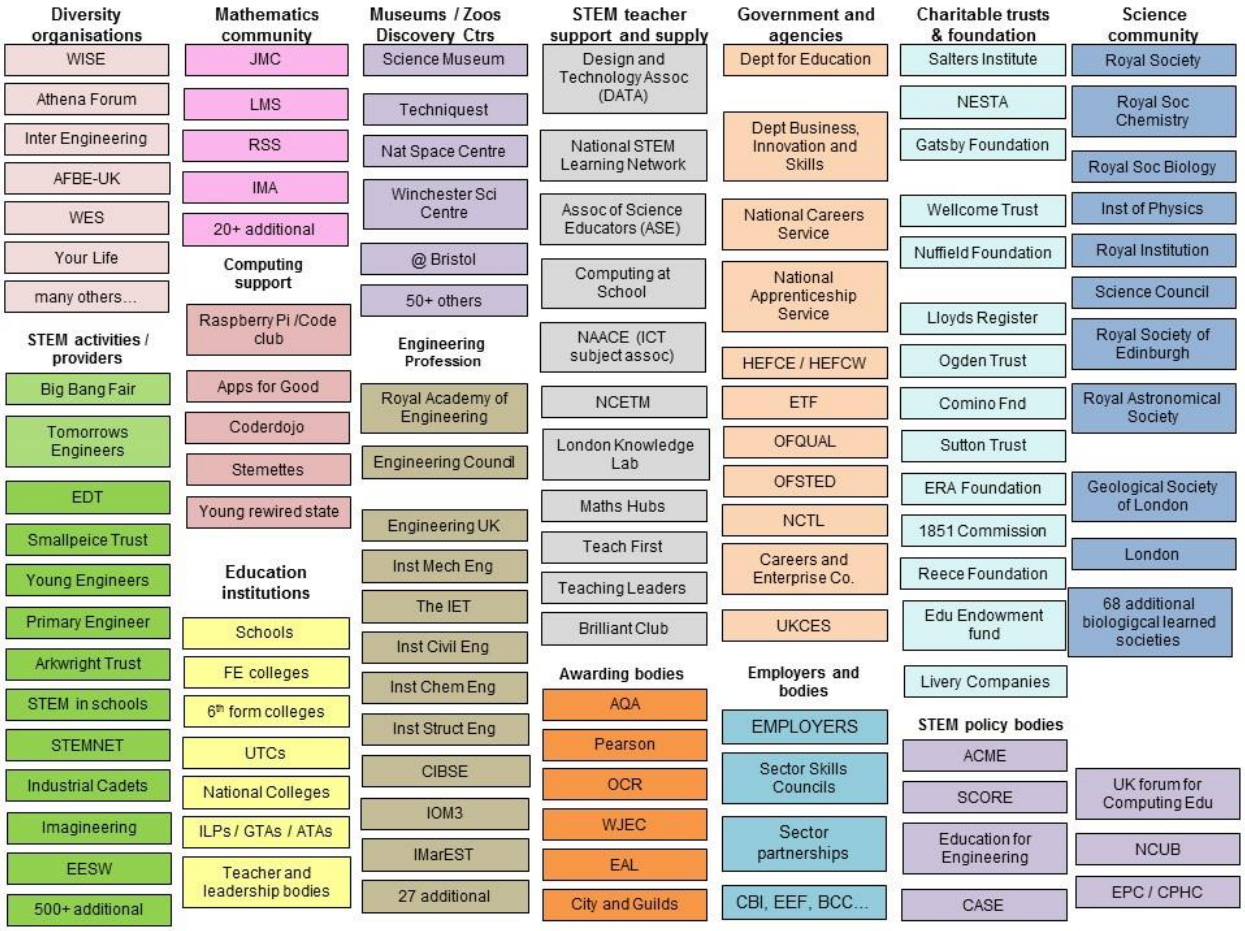

Figure A2: An illustration of the complex STEM education landscape that highlights just a fraction of the organisations engaged in various types of activity[28].

10. To increase the number of young people with the qualifications and interest to consider progressing into engineering occupations, the engineering (and more broadly STEM) communities have been implementing a wide range of initiatives for many years to encourage young people to pursue STEM subjects at school, college and university. In addition, various organisations have been working to improve the quality of teaching and learning across STEM subjects, while others have been

[27] *The UK STEM Education Landscape*, Royal Academy of Engineering and Lloyd's Register Foundation, 2016 http://www.raeng.org.uk/publications/reports/uk-stem-education-landscape

[28] Taken from: *The UK STEM Education Landscape*, Royal Academy of Engineering and Lloyd's Register Foundation, 2016 http://www.raeng.org.uk/publications/reports/uk-stem-education-landscape

working to influence government policy to increase participation and attainment in STEM.

11. The Academy has found that the sheer number and diversity of the many organisations involved in trying to address the UK's engineering skills challenge has created a highly complex landscape which is confusing to all stakeholders and which few people properly understand. The complexity has also led to inefficiencies and has been arguably ineffective in delivering the necessary change. Despite many years of intense activity, there has been limited growth in the key subjects at A level leading to engineering, as shown in **figure A3**. An encouraging trend for mathematics is shown, with around 90,000 students pursuing A level in recent years. However, the growth of other key subjects has been relatively slow and the number of students taking physics remains stubbornly low. Furthermore, the number of UK students graduating from engineering degrees has increased only slightly since 2003, as shown in **figure A4**.

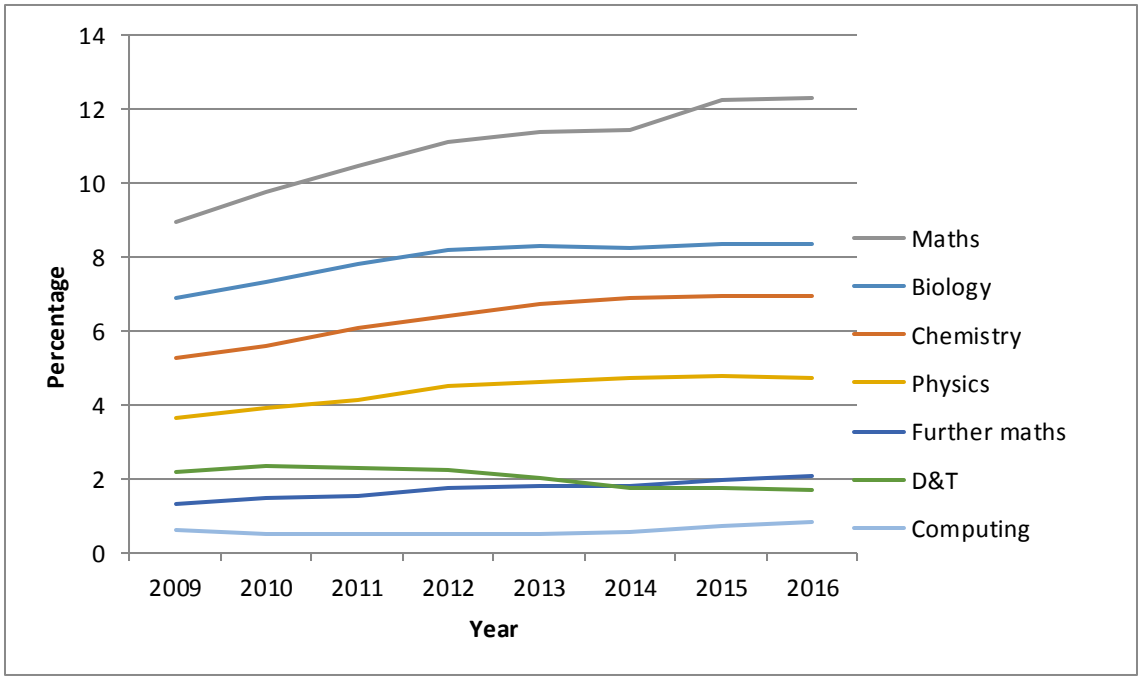

Figure A3: The number of UK A level entries for each subject as a percentage of the total number of 17-year olds[29].

[29] Joint Council for Qualifications.
http://www.jcq.org.uk/
Office for National Statistics
https://www.ons.gov.uk/

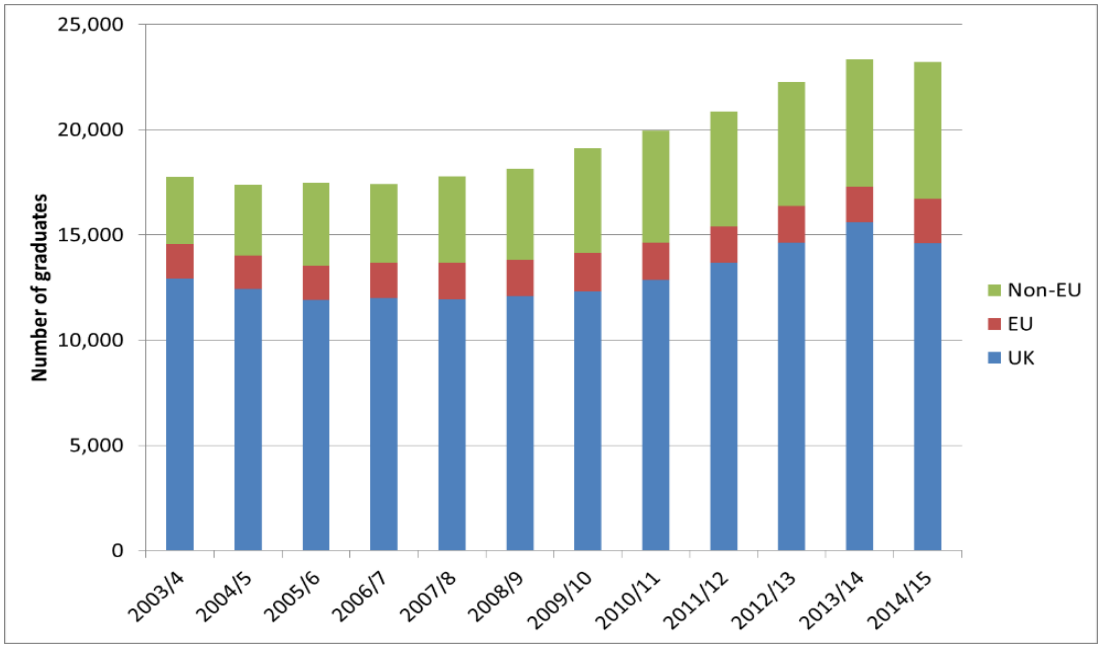

Figure A4: Graduates in UK engineering higher education[30]

12. There are two key organisations that provide some measure of coordination of activity across the various bodies, although engagement with them is voluntary. STEMNET, now run by STEM Learning is the largest coordinator of STEM volunteer engagement activity in England. It delivers three core national programmes to schools: STEM Ambassadors; STEM Clubs Programme; Schools STEM Advisory Network. The second organisation, EngineeringUK, delivers the Tomorrows Engineers programme which aims to create a national network of employers to reduce duplication of effort.

13. A recent positive development has been a review of the functions of STEM Learning and Tomorrows Engineers along with the activities of the Careers and Enterprise Company, to create a 'spine' of coordination for STEM support and employer engagement for all schools in England.

[30] Taken from: *The UK STEM Education Landscape* report, Royal Academy of Engineering and Lloyd's Register Foundation, 2016
http://www.raeng.org.uk/publications/reports/uk-stem-education-landscape
Data from: *Engineering UK 2015: The State of Engineering* report, EngineeringUK, 2015
http://www.engineeringuk.com/EngineeringUK2015/EngUK_Report_2015_Interactive.pdf