Education for Engineering (E4E) is the body through which the engineering profession offers coordinated advice on education and skills policy to UK Government and the devolved Assemblies. It deals with all aspects of learning that underpin engineering. It is hosted by The Royal Academy of Engineering with membership drawn from the professional engineering community including all 35 Professional Engineering Institutions, the Engineering Council and EngineeringUK and the Engineering Professors' Council.

UK engineering has a gender problem

The challenge of achieving gender parity in engineering appears to be particularly difficult for the UK. Figures from 2016 show that 12% of those working in engineering occupations in the engineering sector is female:[1] the lowest percentage of female engineering professionals in Europe, while Latvia, Bulgaria and Cyprus lead with nearly 30%. Some 16% of UK engineering first degree graduates are female,[2] compared to developing economies such as Myanmar, Tunisia and Honduras which have the highest proportion of female engineering graduates: 65%, 42% and 41% respectively[3]. The number of women registered as engineers and technicians in the UK is slowly increasing, from 4.8% in 2015 to 5.2% in 2016,[4] although it is important not to conflate registration with working as an engineer. The lack of women at senior levels and in occupations that pay higher salaries who can act as role models and trailblazers is also a cause for concern.

Any attempt to understand and address this imbalance must be undertaken with the implicit recognition that women are not a homogenous group but individuals with many other identity points who will be differentially impacted by forces including gender, socio-economic group, and ethnicity.[5] These contextual realities of women's lives and experiences mean more nuanced approaches and solutions are required to address the engineering gender imbalance; one size will not fit all.

The long-standing underrepresentation of women in the engineering sector is culturally deep rooted. If not addressed as a matter of priority, it may lead to complacency whereby the accepted narrative becomes that females are simply less interested in engineering and the motivation and willingness to address the issue wanes.

Engineering is misunderstood

Engineering itself is a vastly diverse discipline with a wide range of academic and vocational entry points across all levels and encompassing many different activities from being at the forefront of artificial intelligence developments, designing the cities of the future, to helping ensure clean water supplies to developing countries. Despite the pervasiveness of engineering in our lives, it is too often poorly understood and unrecognised which means that large sections of the population are unaware of its economic value to the UK and the sheer breadth of opportunities that lead to a fulfilling career in engineering. The Royal Academy of Engineering's This is Engineering campaign

[1] Engineering UK 2018: The state of engineering. Available at: http://www.engineeringuk.com/report-2018

[2] HESA (2017) *SFR242: Higher education student enrolments and qualifications obtained at higher education providers in the United Kingdom 2015/16.* Available at: https://www.hesa.ac.uk/news/12-01-2017/sfr242-student-enrolments-and-qualifications (accessed 29 May 2018)

[3] Centre for Economics and Business Research *: Engineering and Economic Growth: a global view.* Available at: http://www.raeng.org.uk/policy/international-policy-and-development/engineering-a-better-world-caets-2016/economic-research (accessed 31 May 2018)

[4] Engineering Council (2017) *Rise in number of professionally registered women engineers and technicians*. Available at: https://www.engc.org.uk/news/press-releases/pr2017/rise-in-number-of-professionally-registered-women-engineers-and-technicians-according-to-engineering-council-report/ (accessed 29 May 2018)

[5] Equality Challenge Unit *ASSET 2016: Experiences surrounding gender equality in STEMM academia and the intersections with ethnicity, sexual orientation, disability and age.* Available at: https://www.ecu.ac.uk/publications/asset-2016/ (accessed 30 May 2018)

was launched in January 2018 with support from major engineering organisations to present a positive image of modern engineering to young people to help combat this perception.[6]

Engineering must reflect the UK population

Engineering is an intrinsic part of the nation's economic and cultural experience and there are few areas of our lives and policy debate that are unaffected by it. Consequently, there is a clear rationale for ensuring that the sector reflects the population it serves, both as the consumers of its products and the funders of its projects. It is right for reasons of social justice that the governance of engineering should also represent wider society. This is true within the profession where an inclusive environment means everyone is treated fairly and respectfully. Engineering is at its heart about identifying the issues and devising the solutions that improve peoples' lives. Ensuring the people who identify these issues and devise these solutions are from a diverse range of backgrounds with different experiences will help remove the status quo as the world will no longer be shaped from the perspective of the dominant empowered groups.[7]

Undersupply of engineers

The business imperative is there with an average annual demand to fill 124,000 Level 3+ core engineering roles through to 2024. There is also an estimated additional annual requirement for 79,000 'related' roles requiring a mixed application of engineering knowledge and skills alongside other skill sets.[8] The supply side of this equation will also come under increasing pressure with Britain's forthcoming exit from the EU which will likely lead to the end of free movement and with it the ability of non-UK EU engineers to work in this country. This necessitates improving and securing UK engineering talent pipelines and ensuring the pools drawn from them are as wide as possible. Engineering, with its creative design-based skillset, is also far more likely to be resistant to the increasing pace of automation and other technologies and thus can be seen as a way of future proofing for the Fourth Industrial Revolution.[9] The business case for diversity in the workforce leading to enhanced performance is increasingly recognised and evidenced: it shows that, inter alia, a diverse and inclusive workforce will improve motivation, performance, retention,[10] group problem solving[11] and financial performance.[12]

Routes into engineering for older people

Although the inquiry questions do not focus on the issue of opportunities for older people, including women, to access education and training opportunities, we believe this is an important one. The Fourth Industrial Revolution and the changing nature of work means that opportunities for workers to retrain and improve their knowledge and skills are vital for the UK economy to remain agile. At a time when government initiatives such as the industrial strategy explicitly recognise the importance of lifelong learning, there is a dearth of education and training options designed to be accessible and convenient to the adult learner. Opportunities for adults to access education and retraining have rapidly declined with decreasing central funding, evidenced by the steep drop-off in part time students (experiencing a 30% fall in numbers in 2015/16 compared to 2011/12).[13] This

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[6] Royal Academy of Engineering *This is Engineering.* Available at: https://www.raeng.org.uk/education/this-is-engineering (accessed 29 May 2018)

[7] See for example: The Times of India (31 January 2017) *Lack of sanitation facilities puts high burden on women: Survey.* Available at: https://timesofindia.indiatimes.com/business/india-business/lack-of-sanitation-facilities-puts-high-burden-on-womensurvey/articleshow/56893332.cms (accessed 30 May 2018)

[8] Engineering UK 2018: The state of engineering. Available at: http://www.engineeringuk.com/report-2018

[9] Nesta *Creativity vs Robots.* Available at: https://www.nesta.org.uk/feature/future-shock/creativity-vs-robots/ (accessed 30 May 2018)

[10] Royal Academy of Engineering (2017) *Creating cultures where all engineers thrive.* Available at: https://www.raeng.org.uk/publications/reports/creating-cultures-where-all-engineers-thrive (accessed 29 May 2018)

[11] KelloggInsight (2010) *Better decisions through diversity: heterogeneity can boost group performance.* Available at: https://insight.kellogg.northwestern.edu/article/better_decisions_through_diversity (accessed 30 May 2018)

[12] McKinsey&Company (2018) *Delivering through diversity.* Available at: https://www.mckinsey.com/~/media/McKinsey/Business%20Functions/Organization/Our%20Insights/Delivering%20through%20diversity/Delivering-through-diversity_full-report.ashx (accessed 30 May 2018)

[13] HESA (2017) *SFR242: Higher education student enrolments and qualifications obtained at higher education providers in the United Kingdom 2015/16.* Available at: https://www.hesa.ac.uk/news/12-01-2017/sfr242-student-enrolments-and-qualifications (accessed 29 May 2018)

is a particularly important issue for women: mature students are more likely to be female than male,[14] and women are also more likely to study part-time than men.[15]

We believe the current framework for continuing further study is too complex and rigid and does not respond to the needs of the market. Notable exceptions to this include: Birkbeck providing part-time evening courses, and the Open University providing part-time, online distance learning. These institutions, however, are not the right provider for all part-time and flexible-learning students, and further models need to be developed to target a range of potential students.

Efforts to reduce the skills gap should explore novel routes into engineering for prospective mature students/learners that exist alongside other policy contexts. These could include, for example, ensure that funding for retraining and childcare solutions are available to encourage more women to return to work after a career break (two-thirds of female engineers leave the profession after taking maternity leave[16]) or to retrain as an engineer after a career break. The current loan repayment system means that individual who which to embark upon a HE course have a shorter repayment period, and therefore will pay back less of their loan in that time. This perceived negative association of never paying off the debt may discourage some prospective mature students. Moreover, the choice of course is often directed by the employer.

Greater flexibility in employee training is especially important for SMEs. An incremental approach to lateral and up-skilling will allow learners in the workplace to gain skills in an area of need at a time that suits them. For example, many engineers are technically capable but require training in other areas as they respond to technological advances and/or move into a more strategic or managerial role in their career. The development of hop on/hop off courses that a student could take at times that suit their circumstances (or the needs of their employer), with an opportunity to accumulate and transfer credits, would therefore be particularly important to the engineering sector. A flexible funding model to accommodate a wide variety of study patterns would be required so that providers can offer flexible courses. Indirect facilitation costs (that make it impractical or impossible for an individual to enter study – such as childcare costs) must also be considered.

A-level subject choices may preclude students from engineering degree courses, and this is particularly relevant for women: just 27% of girls' A-level entries in 2017 were in STEM subjects, compared with 46% of boy's entries.[17] Opportunities for students to develop their engineering-relevant knowledge and skill set before further study are therefore also necessary. This could also take the form of a foundation degree 'transition into engineering' course with the option to transfer to a BEng or MEng (already offered at a small number of institutions, but only as a full-time course[18]), or hop on/hop off courses that could fit around the student's circumstances. Another potential flexible route into the engineering sector for mature students is a 'conversion into engineering' course, similar to the law conversion course.

1.What are the key barriers for women considering a career in engineering across levels 2-6? (including culture and aspects of the work environment)

Perceptions of engineering

[14] UCAS (2017) *End of Cycle 2017 Data Resources: DR2_017_01 acceptances by age and sex.* Available at: https://www.ucas.com/corporate/data-and-analysis/ucas-undergraduate-releases/ucas-undergraduate-end-cycle-data-resources/applicants-and-acceptances-groups-applicants-2017 (Accessed 30 May 2018)

[15] HESA (2017) *SFR242: Higher education student enrolments and qualifications obtained at higher education providers in the United Kingdom 2015/16.* Available at: https://www.hesa.ac.uk/news/12-01-2017/sfr242-student-enrolments-and-qualifications (accessed 29 May 2018)

[16] Institution of Mechanical Engineers (2017) *Stay or go? The experience of female engineers in early career.* Available at: https://www.imeche.org/policy-and-press/reports/detail/stay-or-go.-the-experience-of-female-engineers-in-early-career (accessed 30 May 2018)

[17] Engineering UK 2018: The state of engineering. Available at: http://www.engineeringuk.com/report-2018

[18] Search for courses on UCAS website (30 May 2018) applying 'undergraduate', 'engineering' and 'foundation degree' filters https://digital.ucas.com/search/results?SearchText=Engineering+Foundation&AutoSuggestType=coursetitleslist&SearchType=searchbarbutton&PreviouslyAppliedFilters=D_0_Undergraduate__QM_1_Foundation+degrees__&AcademicYearId=2018&ClearingOptOut=False&vacancy-rb=rba&filters=&filters=Destination_Undergraduate&ProviderText=&add=Subject_Engineering&SubjectText=&filters=QualificationMapped_Foundation+degrees&DistanceFromPostcode=1mi&RegionDistancePostcode=&SortOrder=ProviderAtoZ&CurrentView=Provider

In order to achieve gender parity in engineering, it is essential that more girls and women see engineering as both an attractive career option and as one that they can see themselves in and fits with their sense of self. This must start at a young age: just 46% of girls aged 11-14 would consider a career in engineering, compared to 70% of boys, and 25% of girls want to become an engineer, compared to 38% of boys.[19] Such perceptions are not formed in a vacuum and are buttressed by wider cultural pressures and issues around masculine and feminine archetypes and stereotypes and options, specific cultural connotations, and the aspirations of the child and their key influencers.

The task around changing female perspectives though must not be taken as shifting the responsibility to females to simply 'correct' their misconceptions about engineering and their own capabilities. The perceptions and conscious and unconscious bias of others as well as wider societal power structures present very real barriers to women looking to enter engineering as well as those within engineering looking to develop their careers and progress. It is worrying that 29% of male teachers think STEM careers are more for boys than girls,[20] and that parents of boys are more likely to want, and encourage, their child to pursue and engineering career than parents of girls.[21] It should be noted that the perception of engineering as an unsuitable career – especially for females – is particularly prevalent in certain cultures and backgrounds within society, where children may instead be encouraged by their parents into other pathways, such medicine and law that may be regarded as more 'professional'. Similarly, girls may be discouraged by parents, peers and wider societal bias from studying facilitating subjects.

Narrow curriculum

These perceptions could be significantly addressed in schools by providing a broader curriculum for all children that shows the value of and opportunities provided by both technical and creative subjects. The current accountability measures for school actively discourage this and there is no shortage of research and commentary on the displacement effect of Progress 8 and the EBacc on creative and technical subjects.[22] The list of technical qualifications accepted in Progress 8 has recently been significantly reduced: the number of engineering-related technical awards has been reduced from 21 approved for reporting in school performance tables in 2019[23] to just 12 in 2020.[24] Whilst broadening the curriculum would be beneficial for all students regardless of gender, it is likely to have a particular impact on females who are overrepresented in many arts and creative subjects at secondary level and may not view the creative subjects as a valid and valuable route into a rewarding career in engineering. A true baccalaureate approach that requires young people to study more subjects for longer would delay the decision-making process and allow more young people to develop engineering and technological literacy who would otherwise specialise in the arts and humanities.[25] This would also allow those who would otherwise specialise in the physical sciences to study traditionally 'creative' subjects for longer: this has been proven to improve performance in engineering courses at degree level.[26]

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[19] Engineering UK 2018: The state of engineering. Available at: http://www.engineeringuk.com/report-2018

[20] British Gas (2017) *Teachers desperately need support from Britain's businesses to close the STEM skills gap.* Available at: https://www.britishgas.co.uk/media/r/1490/teachers_desperately_need_support_from_britain_s_ (Accessed 29 May 2018)

[21] Department for Business, Innovation and Skills (2013) *Professor John Perkins' Review of Engineering Skills.* Available at: https://www.gov.uk/government/publications/engineering-skills-perkins-review (Accessed 29 May 2018)

[22] See for example: Branwen Jeffreys, BBC (30 January 2018) *Creative subjects being squeezed, schools tell BBC.* Available at: http://www.bbc.co.uk/news/education-42862996 (accessed 30 May 2018) and Helen Ward, TES (7 September 2017) *EBacc is purring art at risk, university warns.* Available at: https://www.tes.com/news/ebacc-putting-art-risk-university-warns (accessed 30 May 2018)

[23] Department for Education (2017) *Guidance: Technical awards.* Available at: https://www.gov.uk/government/publications/2019-performance-tables-technical-and-vocational-qualifications/2019-school-performance-tables-technical-and-applied-qualifications (accessed 30 May 2018)

[24] Department for Education (2018) *Guidance: Technical awards.* Available at: https://www.gov.uk/government/publications/2020-performance-tables-technical-and-vocational-qualifications/technical-awards (accessed 30 May 2018)

[25] Institution of Mechanical Engineers (2016) *Big ideas: the future of engineering in schools.* Available at: https://www.imeche.org/policy-and-press/reports/detail/big-ideas-report-the-future-of-engineering-in-schools (accessed 29 May 2018)

[26] Paul McCombie, University of Bath (2016) *Analysis of graduates with A-levels from 2013-2016 with A*, A or B in subjects shown.* Available at: http://people.bath.ac.uk/abspfm/analysis/ALevelAnalysis.htm (accessed 29 May 2018)

To compound the problem, schools are judged and rewarded on the proportion of students going on to further academic study (most typically university) rather than a more holistic look at student destinations including vocational education, technical awards and apprenticeships.

Teacher shortages

Even the subjects within the EBacc that provide potential pathways into engineering face serious problems in their delivery in schools. There are significant shortages of specialist teachers in engineering-related subjects such as mathematics (only 79% of required teacher recruited in 2017/18), physics (68%) and computing (66%).[27] The picture for engineering-related non-Ebacc subjects is even worse: just 33% of required Design and Technology (D&T) teachers are expected to be recruited in 2017/18. Some areas of the UK and certain types of schools are less likely to seek specialist science teachers than others, and these schools are also less likely to successfully recruit science teachers,[28] reinforcing the disadvantages conferred on some schools and pupils by not having a specially trained committed teacher. Specialist teachers of different subjects are already eligible for different amounts of funding whilst training to become a teacher: a trainee maths teacher can receive an early-career payment of £10,000 on top of a £22,000 scholarship; trainee physics and computing teachers are eligible for a £28,000 scholarship; but a trainee D&T teacher can only receive the maximum bursary of £15,000 if they have a First or a PhD, £9,000 if they have a 2:1 or a Master's, and nothing if they have a 2:2.[29] Predictions have suggested that a small salary supplement for specialist science and maths teachers would eliminate teacher shortages,[30] but the impact on teacher morale, recruitment and retention for ineligible subjects is unclear.

Teacher attrition

Significant teacher attrition (over a quarter of teachers qualified between 2004 and 2013 had left service within 5 years[31]) is recognised as being another key issue here[32] and a significant barrier to enabling pupils to receive a broad education to act as a spring board for a variety of careers, including engineering. At least part of this centres on the lack of access to quality continuous professional development (CPD): there is a lack of clarity around teacher entitlement to CPD, no minimum hours, and no requirement for ringfenced funding for subject-specific CPD to encourage enhanced subject engagement and knowledge (rather than management techniques). The UK's teaching workforce lacks a serious culture of employee-owned and initiated CPD and the only way to begin the process of embedding this is through serious investment.

Teacher CPD

Engineering related subjects, most obviously D&T, have an enhanced need for up to date industrial knowledge to maintain subject relevance. The pace of change of new knowledge and pedagogies requires more frequent professional development. In addition, the engineering community believes that there is a clear need for teachers in science, computing, D&T, and mathematics to provide real-life contexts to the theory that they teach, to make the subjects relevant and inspiring for young people, and especially to deliver them in ways that are engaging to female students. There are many teacher CPD programmes available that support STEM teachers: the Royal Academy of Engineering's Connecting STEM Teachers programme, the Institute of Physics Stimulating Physics Network, the National Centre for Excellence in the Teaching of Mathematics' Maths Hubs and the

[27] NCTL census data. Available at: https://www.gov.uk/government/collections/statistics-teacher-training (accessed 30 May 2018)

[28] Gatsby Foundation (2018) *Specialist science teacher recruitment in England 2016-2017.* Available at: http://www.gatsby.org.uk/uploads/education/specialist-science-teacher-recruitment-2016-2017-310118.pdf (accessed 29 May 2018)

[29] Get into Teaching bursaries and funding. Available at: https://getintoteaching.education.gov.uk/funding-and-salary/overview (accessed 30 May 2018)

[30] Gatsby Foundation (2017) *What happens when you pay shortage-subject teachers more money? Simulating the effect of early-career salary supplements on teacher supply in England.* Available at: http://www.gatsby.org.uk/uploads/education/datalab-simulating-the-effect-of-early-career-salary-supplements-on-teacher-supply-in-england.pdf (accessed 30 May 2019)

[31] National Audit Office (2016) *Training New Teachers.* Available at: https://www.nao.org.uk/report/training-new-teachers/ (accessed 29 May 2018)

[32] See for example: Katherine Sellgren, BBC (31 January 2018) *Teacher retention: Government 'failing to get a grip'* Available at: http://www.bbc.co.uk/news/education-42873153 (accessed 30 May 2018)

Computing at School Master Teacher Network; as well as STEM Learning's bursary scheme Project Enthuse, allowing teachers to attend courses for free. The engineering community has particular interest in the programmes that develop a greater knowledge of engineering for STEM teachers. The STEM Insight scheme, developed by the professional engineering institutions and delivered by STEM Learning, provides work placements in industry for teachers and the Connecting STEM Teachers programme delivers training for teachers across STEM subjects in over 700 schools with contextualised engineering resources.

With the introduction of academies and free schools in England over recent years, governance of the education system has become more diverse and traditional networks of teacher support provided by the local authorities have been supplanted by other structures. Previously, local authority advisers would facilitate the sharing of expensive equipment between schools and co-ordinate the interaction of teachers at different schools, organising their redeployment if necessary. These services now take place on an ad hoc basis with funding from other sources. There is a need or a central sustainable co-ordination and signposting system. Options should be explored to manage redeployment by retraining and reassigning teachers to other schools in areas of need.

STEM statistics can be misleading

Although 'STEM in schools' remains a popular rallying cry, it is not necessarily a helpful one as in reality the sciences and maths are emphasised whilst technology and engineering are side-lined and neglected. In particular, biology skews our perception of gender participation in STEM: 62% of biology A-level entrants are female, compared to 10% of computing, 22% of physics, 38% of D&T, 39% of maths and 28% of further maths entrants.[33] Even the number of female computing, physics, D&T and further maths students combined is not significantly larger than the number of female biology students (maths is the single most popular subject at A-level).

While the proportional growth rate of women starting a first degree in engineering and technology is steady and significant (an increase of 23% from 2005-2015) the numbers remain small with female engineering entrants totalling 5960 in 2015 compared with 31,375 men.[34] Although graduates with an engineering and technology degree enjoy the second highest average starting salaries of all subjects (£27,079, just behind medicine and dentistry), females still earn less than their male counterparts (£25,959 vs £27,260). An Academy report on employment destinations of undergraduate engineers is similarly superficially encouraging: roughly the same proportion of female graduates as their male counterparts go into engineering occupations surveyed at 6 months (approximately 55%). Over the longer term, however, our analysis shows that 60% of female engineering graduates are in engineering jobs compared with 70% of male graduates. One US study found that 40 per cent of women with engineering degrees had either left the industry or never entered it.

Women in the engineering profession

The recruitment of females into engineering clearly does not function separately from the experience of women already in this workforce. In other words, the perception of engineering as a career is influenced by the communication of female experiences of engineering as a career, indicating that visible role models are important. In a survey of 300 female engineers, 84% were happy or extremely happy with their career choice,[35] but this is not reflected in professional registration retention: 57% of women give up their registration by the age of 45 compared with 16% of men. There are also barriers to returning to an engineering career: 60% of women in STEM who had taken a maternity or career break felt their return to work was hindered or prevented by a variety of barriers, including financial, such as the cost of childcare (52%), unavailability of flexible working patterns (27%), and lack of training, support and guidance (25%).[36] Two-thirds of female

[33] Engineering UK 2018: The state of engineering. Available at: http://www.engineeringuk.com/report-2018
[34] Engineering UK 2018: The state of engineering. Available at: http://www.engineeringuk.com/report-2018
[35] Royal Academy of Engineering (2013) *Britain's got talented female engineers.* Available at: https://www.raeng.org.uk/publications/other/britains-got-talented-female-engineers (accessed 30 May 2018)
[36] Women's Engineering Society (2015) *Women in STEM: are you in or out? Survey overview.* Available at: https://www.wes.org.uk/sites/default/files/u82/Women%20in%20STEM%20-%20In%20Or%20Out%20Summary%20Report%20Final%202015.pdf (accessed 30 May 2018)

engineers do not return to work in engineering after taking maternity leave.[37] If women feel unsupported in engineering, they may choose to leave to find jobs in other industries. Training, development, access to challenging work and support have been identified as factors that are crucial to retaining women within engineering. Even in workplaces with an apparently family friendly culture and flexible-working opportunities, those who take advantage of these are seen as lacking 'commitment' and their career progression is held back.

2. Do you have any examples from firms or educational institutions with particularly good or bad practice as an environment for women in engineering? (Please share examples ***without naming*** *the firm or educational institution)*

It is important to facilitate the identification and sharing of best practice within the sector. Part of this includes identifying precisely what is effective in the recruitment and, crucially retention of a gender balanced workforce.

In terms of education, we note that female single sex secondary schools tend to outperform both boys' schools and mixed schools.[38] This holds true even when only state schools are compared, and when prior attainment is taken into account, although it is also possible that single-sex girls schools tend to have lower levels of social deprivation. It is not clear what causes this difference in performance, but it could be due to a reduced level of gender stereotyping occurring at girls' schools,[39] teaching styles targeted at girls (girls and boys often have different learning patterns),[40] and a greater sense of belonging experienced by girls at single-sex schools.[41] The type of school also influences the likelihood of girls studying engineering-facilitating subjects: girls are two and a half times more likely to study A-level Physics if they are at a girls' school than a co-ed school, and twice as many girls went on to study A-level Physics from schools with a sixth form compared to schools that only teach up to age 16.[42]

We are aware of a non-selective academy with a significantly more gender-balanced uptake of engineering than is seen nationally: girls make up 30-35% of GCSE classes and the 2016/17 A-level class had an even gender split. All year 7 students at the school receive three hours engineering teaching a week, and year 8 and 9 students 2 hours a week, from the dedicated engineering department (instead of a conventional D&T department). The department's facilities are well resourced, with gender-balanced staff, a significant proportion of whom have taken a combined engineering and education degree course. Teaching has a strong focus on social context with a focus on practical problem solving.

One engineering company has recently altered its graduate recruitment advertising strategy from focusing on individuals who could fill the immediate needs of predefined openings to high calibre individuals who could develop in the role to meet the future needs of the business. Targeting both students graduating from engineering degrees and students from 'associated' STEM subjects (such as maths, physics and chemistry) attracted a broader, more gender balanced candidate pool, with offers made based on merit, resulting in a graduate intake which is 37% female.

Within higher education, there are a number of initiatives to encourage more women to study engineering. Many of the good ones tend to be run by different universities but there would be benefits to assimilating the many independent initiatives at all levels. One university has restructured its engineering outreach and engagement programmes for young people. The strategy focusses on building pupils' engineering experiences over a period of time from an early age, with opportunities for them to take part in real-life practical engineering challenges. These activities are

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[37] Institution of Mechanical Engineers (2016) *Big ideas: the future of engineering in schools.* Available at: https://www.imeche.org/policy-and-press/reports/detail/big-ideas-report-the-future-of-engineering-in-schools (accessed 29 May 2018)

[38] Timo Hannay, SchoolDash (27 January 2016) *Single-sex schools: cui bono?* Available at: https://www.schooldash.com/blog-1601.html#20160127 (accessed 30 May 2018)

[39] Institute of Physics (2012) *It's different for girls: the influence of schools*. Available at: http://www.iop.org/education/teacher/support/girls_physics/file_58196.pdf (accessed 30 May 2018)

[40] Institute of Physics (2006) *Girls in the physics classroom: a review of the research on the participation of girls in physics*. Available at: https://www.iop.org/education/teacher/support/girls_physics/review/file_41599.pdf (accessed 30 May 2018)

[41] ibid

[42] Institute of Physics (2012) *It's different for girls: the influence of schools*. Available at: http://www.iop.org/education/teacher/support/girls_physics/file_58196.pdf (accessed 30 May 2018)

reinforced in classroom learning, facilitated by providing CPD for teachers. Young people have opportunities to meet inspirational relatable engineering role models, who help htem discover pathways into STEM careers. Although the ultimate aim of the strategy is to strengthen and diversify the engineering workforce by encouraging young people from a variety of backgrounds to consider a career in engineering, the programme will also raise awareness of what engineering is and how it contributes to society, and improve young people's confidence.

Our own collective experience does show there are many encouraging examples out there of institutions and schools that are tackling this issue effectively and we encourage identification of the key features in common: flexible working practices (including flexitime, job sharing, condensed hours, part-time opportunities and opportunities to work from home), opportunities for mentoring and professional development, sponsorship, and using positive action to target, encourage and empower young women so they feel able to succeed in that environment. We would like to highlight the work the Institution of Physics has done in researching the effectiveness of various initiatives to increase gender equality in schools[43] and the set of guidelines and recommendations for schools they have generated as a result of this research.

3. What practical steps can be taken to address these barriers?

a. Do we specialise too early?

The impact of early specialisation on diversity in engineering courses and the engineering profession is discussed in a 2016 report by the Academy and the Institution of Mechanical Engineers.[44] To widen participation, it is important to understand at what points girls and women drop out of potential pathways into engineering employment. These routes into engineering are characterised as 'leaky pipelines', in that women are lost to the sector at each educational stage.

This is compounded by the UK being something of an international outlier in requiring educational specialisation at a relatively early age. We think the current system is not working optimally for females or males in allowing and encouraging individuals to reach their potential. The requirement for early specialisation particularly affects the future career paths of women, though: female engineering apprentices and undergraduates make career decisions later than male counterparts, and so are less likely to choose to study subjects that will facilitate their path into their desired career.

According to an IPPR report[45] on women in engineering, students in many parts of Europe are obliged to study at least one of the three sciences to the age of 18. In the UK, the secondary school curriculum of A-levels, by contrast, tends to lead to early specialisation, and the UK is one of a number of countries that offers science as an optional, specialist branch. Comparisons across EU countries show that a lower proportion of girls in England, Wales and Northern Ireland choose to study maths and physics at the age of 18 than those in Italy and Sweden – both of which have a higher proportion of female engineers than the UK. These subjects are important in determining whether potential candidates can go on to pursue an academic route into engineering. The UK's educational structure means that students can opt out of learning science subjects altogether in their final years of school. Removing the opportunity to opt out of particular subjects such as science and maths during the final years of school may be one way to widen career pathways, particularly in the sciences.

It is when making decisions about GCSE subjects that the first of several leaks in the supply of future female engineers arises. The proportions of boys and girls taking GCSEs in mathematics and physics (the pre-requisite subjects for progression towards professional engineering occupations) is the same – with approximately 300,000 girls and 300,000 boys each year taking the subject. In

[43] Institute of Physics (2017) *Improving Gender Balance: Reflections on the impact of interventions in schools*. Available at: http://www.iop.org/education/teacher/support/girls_physics/reports-and-research/improving-gender-balance/page_69157.html (accessed 30 May 2018)

[44] Institution of Mechanical Engineers (2016) *Big ideas: the future of engineering in schools.* Available at: https://www.imeche.org/policy-and-press/reports/detail/big-ideas-report-the-future-of-engineering-in-schools (accessed 29 May 2018)

[45] Institute for Public Policy Research (2014) *Women in engineering: fixing the talent pipeline.* Available at: http://www.ippr.org/files/publications/pdf/women-in-engineering_Sept2014.pdf?noredirect=1 (accessed 30 May 2018)

terms of attainment in the subjects, girls marginally outperform boys. Other subjects relevant to engineering feature a significant gender bias, including D&T (39% female), computing (20%) and engineering (10%).[46]

By A-level, only 2% of girls are choosing A levels in both maths and physics. By now girls represent around 20% of the cohort: around 30,000 students in total with approximately 25,000 boys and 6,000 girls. For vocational pathways at Post-16 education, girls are even more under-represented with only 8% starting apprenticeships in engineering-based disciplines in 2015/16.[47]

When it comes to higher education choices, engineering courses attract the lowest proportion of female applicants after computer sciences: only 16% of engineering and technology first degrees were awarded to females. This proportion increases to 23% of taught postgraduate students and 25% of research postgraduate students.[48] This level of interest in continuing engineering education indicates that women could be more effectively targeted to progress into and stay in a career in engineering. In addition to the low representation of female students, engineering and technology accounts for the lowest proportion of female staff members in higher education, at 17.3% which may negatively affect female perceptions of both the subject and sector in general.

Would introducing engineering from a younger age help?

In short: yes.

A fundamental difficulty in raising awareness of the importance of engineering to all our lives and its attractiveness as a career option is the lack of an obvious host subject in school. The closest candidates are computing and D&T. We fully support the latter's recent GCSE specification (replacing the previous seven available routes) which takes the subject back to its design roots by focusing on possible solutions by making a working prototype instead of a finished product. The contextual based problems allow students to creatively find solutions and identify gaps in the current market, rather than simply being commissioned to make a product. However, the current state of D&T is highly vulnerable with the pressures of the EBacc directing resources (money and time) firmly away from this route. This has resulted in schools drastically reducing and even closing their D&T option. Even if a school does offer D&T, the narrow focus on the EBacc incentivises many to discourage their brighter students from taking it in an attempt to boost their standing in narrow data-driven school performance tables, and from the (deep rooted UK cultural) belief that the knowledge and skills gained by studying an 'academic' subject trumps those gained from a 'technical' subject.

b. *Some universities have removed Physics as an A-level requirement for (some) Engineering Degrees. To what extent are such pre-requisites (at all levels) a practical barrier for students entering engineering courses? Should they be removed?*

Several prestigious universities still require prospective students to have studied maths, physics and, in some cases, further maths A-level.[49] There is a significant gender split in physics (22%) and further maths (28%) at A-level,[50] which may mean these universities are indirectly discriminating against potential female students.

It is not entirely clear why female students are not studying physics at A-level. It is known that the gender balance in progression to A-level physics in co-ed state schools correlates strongly with the gender balance in progression to five other traditionally gender imbalanced A-level subjects (economics, maths, biology, English and psychology).[51] This suggests that factors limiting the

[46] Engineering UK 2018: The state of engineering. Available at: http://www.engineeringuk.com/report-2018
[47] Engineering UK 2018: The state of engineering. Available at: http://www.engineeringuk.com/report-2018
[48] Engineering UK 2018: The state of engineering. Available at: http://www.engineeringuk.com/report-2018
[49] See for example: http://www.imperial.ac.uk/aeronautics/study/ug/requirements/
https://www.undergraduate.study.cam.ac.uk/courses/engineering
http://www.eng.ox.ac.uk/study-here/undergraduate/applying-for-admission/entry-requirements
[50] Engineering UK 2018: The state of engineering. Available at: http://www.engineeringuk.com/report-2018
[51] Institute of Physics (2013) *Closing doors: exploring gender and subject choice in schools.* Available at: http://www.iop.org/publications/iop/2013/closingdoors/ (accessed 30 May 2018)

progression of girls to A-level physics in school are likely to depend on the whole school environment. Schools with sixth forms tend to be more gender-balanced than schools without; independent co-ed schools tend to be more gender-balanced than state co-ed schools; and while pupils are less likely to study A-level physics if they are at a school with higher a proportion of pupils receiving free school meals, this has no effect on gender balance.[52]

44% of schools with girls did not enter any girls for A-level physics in 2016, compared with 17% for boys.[53] There is a significant difference between single-sex and co-ed schools: both boys and girls are more likely to study physics A-level if they are at a single sex school, but girls are especially more likely to study A-level physics. 9% of all school sixth forms had no entrants – of either gender - to A-level physics in 2013/14.[54] The indirect discrimination against those who have not studied A-level physics affects a variety of potential students – not just girls.

Some very prestigious universities successfully teach undergraduate Civil Engineers without physics A-level: for example, Bath, UCL, Leeds and Bristol. Analysis of graduates of Civil Engineering and Civil and Architectural Engineering at the University of Bath has even suggested that students with further maths A-level tend to perform less well over the course of their degree compared to those without.[55] Although removing subject-specific A-level entry requirements has had a positive effect on addressing the gender balance in UCL Civil Engineering undergraduate courses, the effect is relatively small and has since stalled. When the requirement for A-level physics and maths was removed in 2006, just 23% of participants were female (down from 25% the two years before);[56] by 2011 this had reached 30%, but has not changed since then.[57]

If such early and narrow specialisation did not exist in the UK education system then routes into HE engineering would not be cut off to the same extent. It is also possible that some young people do not apply for HE engineering courses because they are under the mistaken impression that all engineering degree courses require Maths and Physics A-levels. A clearer and more effective communication system could allow more young people to believe that a career in engineering would be suitable for them, and that they already have the necessary qualifications to enter an engineering degree.

Males with A-level physics are much more likely to study engineering at university than females with A-level physics.[58] Women evidently experience or perceive further barriers to engineering than the requirement to have studied facilitating subjects. The Engineering Professors' Council's *New Approaches* work, which asked whether improvement in attracting a sufficient pipeline of engineering students is possible, identified two further changes needed in addition to entry criteria for UK HE engineering courses: that the HE engineering curriculum should be refocused away from abstract theory to creating practical solutions to building a better world; and that to create a more diverse profession, positive steps are needed to make courses more appealing and accessible to students of all backgrounds.[59]

c. Is there a role for government policy in relation to the recruitment and/or retention of women into engineering courses and/or engineering occupations? (and if so, what should this role be?)

A broader curriculum at both primary and secondary levels would enable more females (as well as people in general) to progress into engineering courses and occupations as set out above and in

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[52] ibid

[53] Institute of Physics (2018) *Why not physics? A snapshot of girls' uptake at A-level.*

[54] Institute of Physics (2015) *School sixth forms with no entries for A-level physics: a data report.* Available at: http://www.iop.org/publications/iop/2015/file_66691.pdf (accessed 30 May 2018)

[55] Paul McCombie, University of Bath (2016) *Analysis of graduates with A-levels from 2013-2016 with A*, A or B in subjects shown.* Available at: http://people.bath.ac.uk/abspfm/analysis/ALevelAnalysis.htm (accessed 29 May 2018)

[56] UCL Civil, Environmental and Geomatic Engineering (2009) *Athena SWAN Silver award application*. Available at: http://www.ucl.ac.uk/hr/equalities/gender/CEGE_UCL_SWAN.PDF (accessed 30 May 2018)

[57] UCL Civil, Environmental and Geomatic Engineering (2016) *Athena SWAN Silver award application*. Available at: http://www.ucl.ac.uk/hr/equalities/gender/UCL%20CEGE%20Athena%20Swan%202016.pdf (accessed 30 May 2018)

[58] Institute of Physics (2012) *Statistical Report: Degree-Course Destinations of Accepted Applicants with Physics and Mathematics A-level or Scottish Higher 2006-2011.* Available at: http://www.iop.org/publications/iop/2012/file_55895.pdf (accessed 30 May 2018)

[59] Engineering Professors Council (2019) *New approaches to engineering HE: the six facets.* Available at: http://epc.ac.uk/new-approaches-to-engineering-he-the-six-facets/ (accessed 30 May 2018)

the Institution of Mechanical Engineers and Academy's report on the future of engineering in schools.[60]

d. Is there a case for introducing gender-specific quota or targets for over-subscribed programmes that receive government funding? (e.g. apprenticeships)

The use of targets is inevitably controversial. Whilst they can drive the wrong behaviours by encouraging an undue focus on numbers over behaviours and practice, well managed they can provide a welcome spotlight on the issue although the work required to address the root causes of this are a much longer term and complex piece of work.

Targets work most effectively in a comprehensive system, where they are closely interlinked with other mechanisms including awareness-raising and competence development:[61] steps first need to be taken to increase the number of individuals who are eligible to be included in the target. Although targets may result in better representation of women in the roles upon which the target is imposed, unless well-managed, they will not result in changes at the wider organisational level.[62] Equal opportunity will not result solely from the imposition of a target.

Although significant structural change is required, this will not be instantaneous and there are actions we can take in the meantime to ensure that the pipeline is widened. Changing some working practises will benefit all workers, with the additional advantage of particularly benefitting women whose circumstances mean they are particularly vulnerable to leaving their career in engineering, have difficulty re-entering the sector, or cannot enter it in the first place. These include individuals with childcare and caring responsibilities, who may benefit from flexible working patterns and shared parental leave.

Evidence shows that the effectiveness of quotas depends on the environment of the local labour and educational markets and the nature of the profession and organisation.[63] It is already known that different strategies to promote women are more effective in different cultures.[64] It therefore follows that blindly implementing a centrally imposed target will be ineffective. Instead, creating individual targets, based on the local talent pool and the profession in question, will be more successful. Targets could be increased over time as the local talent pool (developed through outreach programmes and other schemes) increases.

Even if targets are not set, data on the gender split in government funded programmes should nevertheless be collected and reported. This would still provide a competitive mechanism for schemes to improve their gender balance and highlight problem areas. Any data gathered would have to be suitably granular to ensure that particular occupations, for example, do not skew the data. Instead of a snapshot approach, data should be gathered and reported regularly (as will now happen with gender pay gap reporting). Organisations will therefore have a mechanism to understand what initiatives constitute best practise, and organisations with low progression rates will be motivated to improve them. Building on the need to report the gender pay gap, private sector firms could be mandated to report on the representation of women within each pay quartile and the movement of women between quartiles, thus increasing transparency and opportunity for challenge which might motivate some to take action.

The experience of Scandinavia where quotas were introduced for female representation on corporate boards produced a "golden circle" effect with the same women being on numerous boards,

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[60] Institution of Mechanical Engineers (2016) *Big ideas: the future of engineering in schools.* Available at: https://www.imeche.org/policy-and-press/reports/detail/big-ideas-report-the-future-of-engineering-in-schools (accessed 29 May 2018)

[61] European Institute for Gender Equality (2016) *Advancing gender equality in political decision-making - Good Practices.* Available at: http://eige.europa.eu/rdc/eige-publications/advancing-gender-equality-political-decision-making-good-practices (accessed 30 May 2018)

[62] Manuel Bagues, Pamela Campa, Vox (9 September 2017) *Electoral gender quotas fail to empower women.* Available at: https://voxeu.org/article/electoral-gender-quotas-fail-empower-women (accessed 30 May 2018)

[63] Edwin Ip, The Conversation (7 August 2017) *Gender quotas can work but it depends on how employers feel about them.* Available at: https://theconversation.com/gender-quotas-can-work-but-it-depends-on-how-employees-feel-about-them-81386 (accessed 30 May 2018)

[64] Harvard Business Review (16 July 2018) *Strategies to promote women should vary across cultures.* Available at: https://hbr.org/2014/07/strategies-to-promote-women-should-vary-across-cultures (accessed 30 May 2018)

in other words only benefitting the very top slice of women rather than genuinely widening the opportunities for females in a sustainable way.[65]

Unconscious bias in company culture, recruitment processes and people making decisions may have a significant effect on recruitment and retention of women in engineering. The language of engineering is very masculine, so any communication, websites, job description, etc tend to be written from a male point of view using male language, and so fewer women will apply.[66] Using gender neutral language which appeals to all may have a substantial beneficial effect. If fundamentals like this are not changed, introducing targets/quotas will have no positive effect.

Employer/sector-led initiatives

1. Do you have suggestions for initiatives that might be piloted to encourage more women to apply for engineering courses?

2. If you currently run your own programme/initiative, please outline this:

The Academy has worked individually and collaboratively with the professional engineering institutions, employers, third sector and campaigning organisations to address challenges to increase women and wider diversity in engineering. Since 2011 it has been delivering a programme to increase diversity and inclusion across the engineering profession.[67]

Graduate Engineering Engagement Programme has run successfully as a pilot and is about to launch fully as a programme in June 2018 to address the issues where students and recent graduates are not getting access to the major employers. It is a collaboration with 13 engineering employers working together to encourage more female, ethnic minority and socially disadvantaged to transition into engineering careers.

Industry-led 10 Steps[68] – The programme supports WISE in implementing the 10 steps by inviting employers to sign up and take a systematic approach to support the recruitment and retention of women in STEM.

National Women in Engineering Day (NWED)[69] – initiated by the Women's Engineering Society (WES) on 23 June 2015, NWED throws a spotlight on female engineers by providing a focal point to celebrate achievements of women engineers across the UK and beyond. The Academy actively supports this day and uses it, along with other opportunities such as International Women's Day, to raise the profile of female engineers. Most recently by celebrating Academy female Fellows[70] as potential role models for aspiring engineers everywhere.

EngineeringUK, which works to inspire tomorrow's engineers and increase the talent pipeline into engineering through educational initiatives, runs two national educational programmes. Neither is targeted at encouraging specifically young women into engineering, but have shown to be useful in encouraging girls to consider a career in engineering (see *Q2d*).

The Big Bang UK Young Scientists & Engineers Fair - an award-winning four-day fair that takes place every year, which attracts young people (primarily aged 7-19) from all around the UK. A combination of theatre shows, interactive workshops and exhibits and careers information from STEM professionals, it is the largest celebration of STEM for young people in the UK with over 80,000 visitors in attendance in 2018 over the four days. Notably, the fair achieves almost an equal

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[65] Morten Huse (2011) *The 'golden skirts': changes in board composition following gender quotas on corporate boards.* Available at: https://www.anzam.org/wp-content/uploads/pdf-manager/473_ANZAM2011-148.PDF (accessed 30 May 2018)

[66] See for example: Steve Warnham, Totaljobs (13 November 2017) *Totaljobs study reveals that UK job adverts carry unconscious gender bias.* Available at: https://blog.totaljobs.com/gender-bias (accessed 31 May 2018)

[67] Royal Academy of Engineering (2016) *Diversity programme report 2011-2016.* Available at: http://www.raeng.org.uk/publications/reports/diversity-programme-report (accessed 30 May 2018)

[68] WISE *Industry led ten steps.* Available at: https://www.wisecampaign.org.uk/consultancy/industry-led-ten-steps (accessed 30 May 2018)

[69] Women's Engineering Society (2016) *National women in engineering day.* Available at: http://www.wes.org.uk/nwed (accessed 30 May 2018)

[70] Royal Academy of Engineering *Celebrating leading women in engineering.* Available at: http://www.raeng.org.uk/policy/diversity-in-engineering/diversity-in-our-fellowship (accessed 30 May 2018)

gender split in attendees. Throughout the year, EngineeringUK also run regional Big Bang Fairs ('Big Bang Near Me' and 'Big Bang@School'), and the Big Bang UK Young Scientists and Engineers Competition, which provides young people with the opportunity to build their skills and confidence in project-based work.

Tomorrow's Engineers - a programme of coordinated schools outreach and careers inspiration which seeks to create the next generation of engineers. The principal aim of the TE programme is to improve the quality, reach, diversity, and impact of engineering employers' engagement with young people (primarily aged 11-14). Working closely with employers and other stakeholders, EngineeringUK coordinates STEM outreach activity within schools. Activities under the TE umbrella include:

- Energy Quest - an in-school workshop and follow-on classroom challenge for young people aged 11-14, highlighting careers information, including routes into engineering careers, and providing the opportunity for young people to hear from real life engineers. Schools are also provided with a Carbon Capture and Storage (CCS) kit which can be used by teachers to assist their students understanding the effects of energy resources on the environment.

- EEP Robotics Challenge **-** a curriculum-linked programme involving teams of 11-14 year olds solving real-world engineering, technology, and computing challenges using LEGO Mindstorms Education EV3 sets.

- Around the World **-** an interactive show for young people to discover how engineering can help tackle difficult societal issues, such as climate change and renewable energy.

- Employer support programme **-** a coordinated network of employer engagement activity. EngineeringUK's regional Employer Support Managers (ESMs) build and maintain strong relationships with STEM employers and stakeholders within their designated region and work with them in an advisory capacity to make sure that the activities they deliver in, with, and for schools (such as industry visits or hands-on workshops) are appropriately engaging and impactful. They also work to coordinate the engagement of employers to avoid duplication of efforts and ensure work is targeted.

- Careers information resources **-** a range of resources developed by the engineering community to provide STEM career guidance for young people aged 5-19 and their teachers. These are adaptable to suit both younger and older students, cover regional variations, and promote both traditional and non-traditional routes into STEM careers.

a. What was the rationale behind its development?

The Academy's Diversity and Inclusion Programme recognises that gender is not a single point of identity. Aside from having a gender, all women have an ethnicity, sexual orientation, socio-economic background, ability or disability, and may be older or younger. These characteristics intersect with their gender leading to varied barriers and outcomes for different women. Women should not be treated as an amorphous mass. For this reason the programme addresses ethnicity, age, sexual orientation and disability, as well as gender.

b. What do you find hardest about engaging women and what challenges have you faced?
c. Have you conducted any evaluation on the success of your programme?
d. Is there any key learning that you would like share with any other organisations?

Research by the Academy[71] indicates that any interventions need to be long term to be effective and that long-term evaluation of impact is necessary to inform evaluation. Students from diverse backgrounds require active encouragement to enter the engineering profession. Mentoring is an effective way to engage and support students into engineering, but requires clear aims, outcomes and timescales so both mentors and mentees understand the potential benefits and outcomes.

[71] Royal Academy of Engineering (to be published 25 June 2018) *Improving employment opportunities for diverse engineering graduates: learning from a pilot project 2015-2018*

EngineeringUK's interventions are underpinned by evaluation activities to assess the impact of their effectiveness.

EngineeringUK has run its Engineering Brand Monitor on an annual basis since 2010 to track progress towards achieving our goals. This nationally representative survey of young people, teachers, parents and the general public measures their perceptions and knowledge of engineering.

Participation rates in EngineeringUK's educational programmes among girls are, encouragingly, on par with those of boys (50/50 representation), and an examination of key evaluation indicators suggests that these engagement activities are largely successful: 96% of female participants report having enjoyed the event, 97% agreed that the event showed them that engineering is suitable for both boys and girls, 85% said the event made them feel that a job in engineering would be interesting, and 75% said the event improved their knowledge about what to do next in order to become an engineer. Moreover, young people are consistently more likely to express positive views of STEM, indicate knowledge of engineering, and see the profession as a desirable career path after participating in an EngineeringUK intervention than those within the general population.

3. Are there ways some large employers could support members of their supply chain to encourage the recruitment and/or retention of women? Would it make sense for government to incentivise this in some way?

Large employers should be supporting their supply chains to be more inclusive in recruiting and retaining women and others underrepresented in their workforce. This could be achieved via procurement conditions and actively supported by facilitating appropriate training, sharing guidance and other ways of empowering companies in the supply chains to make appropriate changes where required. Many large employers and government departments are already including diversity and inclusion requirements in their Request for Quote documents, but little progress will be made unless these requirements are included as part of the criteria that tenders are scored against. A lack of understanding of the difference between positive action and positive discrimination also results in a reluctance to press this issue.

4. Would it make sense for some form of kitemark or charter (with similarities to the Athena SWAN Charter in education) to be applied to private sectors firms with reference to gender?

A kitemark scheme can be a useful tool to drive and encourage inclusive organisational behaviour but only in tandem with a systematic review of organisational barriers to diversity and the organisation's inclusion record and a concerted, long term effort to address remove these. The complexities and nuances of gender discrimination inevitably require significant work on areas such as addressing unconscious bias, appropriate training and a working culture that genuinely welcomes, values and empowers women.

The Athena SWAN experience has useful lessons in that it facilitates more collaborative work within and between HEIs, allowing them to identify, but not always address, the issues associated with gender equality in their institutions and departments.[72]

Many institutions reported that activities to improve gender equality were already taking place before Athena SWAN, but the formal charter provided a focal point and embedded informal processes, or led to better communication of the opportunities available to staff.[73] Engagement with Athena SWAN, initially voluntary, increased when the National Institute for Health Research announced it would only shortlist medicals schools that had a minimum of a Silver award for funding[74] as signifying commitment to equality and diversity.

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[72] Equality Challenge Unit (2014) *Evaluating the effectiveness and impact of the Athena SWAN Charter: executive summary.* Available at: https://www.ecu.ac.uk/wp-content/uploads/external/evaluating-the-effectiveness-and-impact-of-the-athena-swan-charter.pdf (accessed 30 May 2018)

[73] Equality Challenge Unit (2011) *Athena SWAN: measuring success 2011.* Available at: https://www.ecu.ac.uk/wp-content/uploads/2015/04/Athena-SWAN-Impact-Report-2011-1.pdf (accessed 30 May 2018)

[74] Medical Schools Council *Athena SWAN.* Available at: https://www.medschools.ac.uk/our-work/equality-inclusivity/athena-swan (accessed 30 May 2018)

The use of powerful leverage such as making achievement of the kitemark a precondition of access to funding can prove an important tipping point in forcing change. Trusting change to a 'business as usual' approach that historically has stymied female entry into and progression within the engineering workforce may no longer be accepted as satisfactory. Whilst an Athena SWAN Charter-style mark is not without its flaws, there are aspects of the model that would work well in the private sector, in particular: requiring institutions to provide in-depth analysis of gender representation at key stages of the education and employment pipeline; producing a 3-year action plan to tackle identified barriers; and putting forward cross-institutional working groups with a senior staff member as a 'champion'. This helps to recognise that the issue is long-standing, requires concerted effort, and necessitates senior leadership buy-in.

It is important to note, however, that SMEs may lack the resources to be able to undertake such schemes effectively, although extra support and the use of employer groupings may facilitate their participation.

Careers, Advice Information and Guidance

1. How can CAIG be used to support women into engineering? (e.g. initiatives that have been tried; ideas you have that could be piloted)

Part of the problem with the perception of engineering as 'male' and 'too hard' is wider ignorance about engineering careers and the 'engineering pathway' among schoolchildren and their key influencers – parents, teachers and career advisers. Teachers and advisers (as well as the young women they influence) hold outdated views on STEM occupations and career paths into engineering are poorly understood by learners. Limited knowledge of the profession among those trusted by young people to provide careers advice has implications on the degree to which they are able to offer accurate and relevant careers guidance/encouragement. EngineeringUK's Engineering Brand Monitor found that 35% of parents indicated they know only a little or almost nothing about what engineers did, and only 36% expressed confidence in giving advice to their children about a career in engineering.[75] Similarly, 42% of teachers expressed a lack of confidence in giving careers advice about engineering. Better careers guidance at key stages would help steer more female students towards mathematics, physics and D&T, and would also help to break down misconceptions about what an engineer does and who can become an engineer. Companies, HEIs, FE colleges and other organisations can also broaden their targeting to attract those with interests in creative arts and design into engineering courses and apprenticeships.

The subjects studied at school do not lend themselves to developing an accurate understanding of what engineering is like as a career. A better understanding could come from careers education and guidance, but the amount of time an individual student spends with a careers advisor is minimal.

Girls and young women must be able to get information that engineering is an attractive career option for many different types of people. *This is Engineering*, the Academy's new multi-year digital campaign which aims to rebrand engineering for young people, may achieve this, but the results will not be evident for some years. Currently less than half of pupils aged 7-19 believe a career in engineering is desirable; parents (71%) and teachers (86%) are more likely to view a career in engineering as desirable.[76] Girls' interest in an engineering career (whether 'considering becoming' or 'want to become' an engineer) drops with age; it is noticeable that girls in every age group are less likely to say they know what engineers do.[77] Conversely, evidence suggests that female engineering apprentices and undergraduates make career decisions later than male counterparts, so young women aged 15-25 should not be neglected by engineering careers initiatives: rather, a sustained campaign aimed at all ages is required. Positive role models could help effect change girls' interest in engineering as a career – but, of course, this requires sufficient women in high levels in industry to act as role models.

Progress has been made and we welcome the government's embedding of the Gatsby principles[78] (as offering a clear framework for schools in how best to provide careers guidance) in the national careers strategy.[79] The challenge now comes in implementing this framework for careers guidance, with different schools achieving widely varying levels of success.[80] Ringfenced funding may be required for schools to ensure more penetrative careers advice is introduced early and is embedded

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[75] Engineering UK 2018: The state of engineering. Available at: http://www.engineeringuk.com/report-2018
[76] Engineering UK 2018: The state of engineering. Available at: http://www.engineeringuk.com/report-2018
[77] Engineering UK 2018: The state of engineering. Available at: http://www.engineeringuk.com/report-2018
[78] Gatsby Foundation (2014) *Good career guidance.* Available at: http://www.gatsby.org.uk/uploads/education/reports/pdf/gatsby-sir-john-holman-good-career-guidance-2014.pdf (accessed 30 May 2018)
[79] Department for Education (2017) *Careers strategy: making the most of everyone's skills and talents.* Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/664319/Careers_strategy.pdf (accessed 30 May 2018)
[80] Gatsby Foundation (2018) *Good career guidance: reaching the Gatsby benchmarks.* Available at: http://www.gatsby.org.uk/uploads/education/good-career-guidance-handbook-digital.pdf (30 May 2018) and The Careers and Enterprise Company (2017) *State of the Nation 2017: careers and enterprise provision in England's schools.* Available at: https://www.careersandenterprise.co.uk/sites/default/files/uploaded/state_of_the_nation_report_digital_updated01.pdf (accessed 30 May 2018)

into the lead up to GCSEs. Current access to careers provision is often 'patterned' as well as patchy, with girls (among other groups) less likely to receive careers education than their peers.[81]

Exposure to the world of work, industry and the diverse range of myriad of engineering careers is critical to increasing the visibility and understanding of engineering. However, the challenges of coordinated and effective industry engagement with schools is well documented[82] from practical issues such as coordination, signposting (for example effective leverage of the STEM ambassadors programme) and communication and the very real difficulties in matching students with quality work placements. There is also a risk that even well-intentioned industry engagement may not demonstrate to female students that engineering is a suitable career choice for them. A white man in a hard hat speaking to a class may simply reinforce stereotypes. Similarly, the designation of role models in engineering to encourage women may risk perpetuating stereotypes and again relies on women being willing (or pressured) to 'stand out' in this way. There are some notable exceptions: Skills for Industry is a successful initiative run by the Design and Technology Association[83] which allows students and teachers to develop industry-relevant knowledge and skills, with the additional opportunity for pupils to engage with potential role models in apprentices. Severn Trent are proactive in engaging and recruiting female apprentices through their Women in Science and Engineering Apprentice Careers Insight Days.

The enterprise education agenda[84] encompasses many of these concerns but without the backing of accountability measures, implementation remains highly uneven.

2. What are parents' perceptions of the sector? How influential are parent's opinions and how can these perceptions be changed?

Both parents and young people (aged 11–14) believe that parents are the most important influencer of young people's career choices: 70% of the young people aged 11–14 interviewed said they would approach their parents for career advice – slightly more than those who would approach their teachers (66%) and career advisers (60%).[85] Family knowledge and encouragement of engineering and engineering careers is important in shaping science aspirations. More specifically, how much science capital[86] a family possesses has measurable impact on their children's aspirations from as early as the age of 14 (and sometimes even earlier). Addressing the lack of science capital available to girls is one way of overcoming the gender imbalance in STEM subjects and engineering occupations. Improving families' knowledge about engineering and the different routes in is likely to lessen the impacts that stereotypes have on shaping career aspirations.

Anecdotally, parents' perceptions of engineering as an attractive career option can be crucial in either encouraging or discouraging their child's fledgling interest in engineering. Ensuring parents see and understand engineering to be a rewarding and attractive career path for daughters as well as sons is necessary in helping increase the flow of females into engineering careers. Part of this is about understanding the priorities of parents (as opposed to young people) when considering potential career paths for their children which encompass perceptions on salary, stability of the sector etc. There are also significant differences in cultural perceptions towards engineering: a greater understanding of these nuances would allow intervention and careers information to be aimed appropriately.

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[81] House of Commons (2016) *Careers education, information, advice and guidance. First Joint Report of the Business, Innovation and Skills and Education Committees of Session 2016-2017.* Available at: https://publications.parliament.uk/pa/cm201617/cmselect/cmese/205/205.pdf (accessed 30 May 2018)

[82] See for example: Ofsted (2016) *Getting ready for work.* Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/577236/Getting_ready_for_work.pdf (accessed 30 May 2018)

[83] Design and Technology Association *Skills for industry in school.* Available at: https://www.data.org.uk/for-partners/skills-for-industry-in-school/ (accessed 30 May 2018)

[84] See Department for Business, Innovation & Skills and Prime Minister's Office (2014) *Enterprise for All: the relevance of enterprise in education.* Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/338749/EnterpriseforAll-lowres-200614.pdf (accessed 30 May 2018)

[85] Engineering UK 2018: The state of engineering. Available at: http://www.engineeringuk.com/report-2018

[86] UCL Institute of Education *Science capital research.* Available at: http://www.ucl.ac.uk/ioe/departments-centres/departments/education-practice-and-society/science-capital-research (accessed 30 May 2018)

Skills Policy Reforms

1. How can recent and upcoming reforms to the skills system be used to support more women in to engineering?

Women are acutely underrepresented among those starting engineering-related apprenticeships (8% in 2015/16):[87] although women are as likely as men to make successful applications, they are less likely to apply for apprenticeships in engineering – instead applying for apprenticeships in a variety of sectors – and are also less likely to make further applications for engineering apprenticeships if their first was unsuccessful.[88] The number of FE colleges continues to decrease, meaning that a vocational route into engineering may become harder the access in some locations (the proportion of applications to engineering-related apprenticeships made by women varies significantly with geographical area within the UK[89]); the vocational route is already complex and difficult for learners to navigate. The number of engineering-related vocational qualification certificates decreased 15% from 2012-2017.[90] Furthermore, boys aged 14-16 are significantly more likely than girls to think being an apprentice is desirable (52% and 30% respectively).[91]

The wider barriers, both general cultural and those more specific to engineering, to gender parity in engineering described above mean that any tweaks focussing on only one area of the skills system are unlikely to achieve any meaningful improvement in female engagement in engineering. Rather a holistic systems approach is needed to address the myriad of factors that make a career in engineering an unattractive and/or unattainable option for too many females.

We would urge that data is collected on gender balance (as well as other characteristics underrepresented in engineering) as the reforms to the skills system bed in so as to monitor whether these new routes are doing anything to redress the gender balance.

2. How can the design of T levels be used to encourage more women to enter the sector?

Currently the T levels are to be introduced as an isolated level 3 qualification (in the sense that no designed lead in from level 2 or pathway to level 4 are clear). Consequently the structural issues described above are not impacted by this and it is difficult to see how T levels alone can bring any significant improvements to engineering's entrenched gender imbalance.

3. As degree apprenticeships grow, how can we support more women to take up these opportunities in engineering?

It is important that there are a variety of pathways available to enter the engineering profession to facilitate the differing circumstances, preferences and learning styles of a variety of applicants. There is anecdotal evidence that women enjoy the 'hands on' nature of degree apprenticeships and this route could be promoted to grow the number of women entering the engineering profession.

In their work to establish an academic sector perspective on creating an effective system of engineering Degree Apprenticeships, the Engineering Professors' Council (EPC)[92] highlights that consideration must be given to the fact that Degree Apprenticeships are likely to attract learners and individuals from groups underrepresented elsewhere in higher education. In the case of engineering, this includes women. Apprentices' needs must be put at the heart of the development of Degree Apprenticeships' in order to make their wider learning experience must be positive and fulfilling. Degree apprenticeships should not represent a dilution of a traditional education, but instead become a gold standard combining the rigours of applied academic learning interwoven with the practical experience of the workplace. In order not to create a substandard brand for

[87] Engineering UK 2018: The state of engineering. Available at: http://www.engineeringuk.com/report-2018

[88] Gatsby Foundation (2018) *Understanding the under-representation of women in engineering apprenticeships.* Available at: http://www.gatsby.org.uk/uploads/education/women-in-engineering-apprenticeships-report.pdf (accessed 30 May 2018)

[89] ibid

[90] Engineering UK 2018: The state of engineering. Available at: http://www.engineeringuk.com/report-2018

[91] Engineering UK 2018: The state of engineering. Available at: http://www.engineeringuk.com/report-2018

[92] www.epc.ac.uk. *Creating the Supergrads* policy paper – addressing the issues that concern the academic community about Degree Apprenticeships – will be published in Autumn 2018. It builds on the Engineering Professors' Council's extensive work, led by Professor Simon Hodgson of Teesside University, establishing a *Toolkit* for academics to develop successful Degree Apprenticeships and on their 2017 discussion paper *Designing Apprenticeships for Success*.

women (and other underrepresented groups) in engineering it is critical that their academic experience is not a compromised version of that provided for traditional degree students.