EngineeringUK briefing

Gender disparity in engineering

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Executive summary

This briefing provides an overview of female underrepresentation in engineering, both those coming through the education and training pipeline into the profession and those working as engineers. It includes findings from our Engineering Brand Monitor, a national survey of young people and the public more generally into their knowledge, perceptions and understanding of the profession, to provide some insight into this gender imbalance.

Women remain severely underrepresented in engineering: **just 12% of those working in engineering are female, compared with 47% of the overall UK workforce**, despite concerted efforts over many years to address this imbalance.

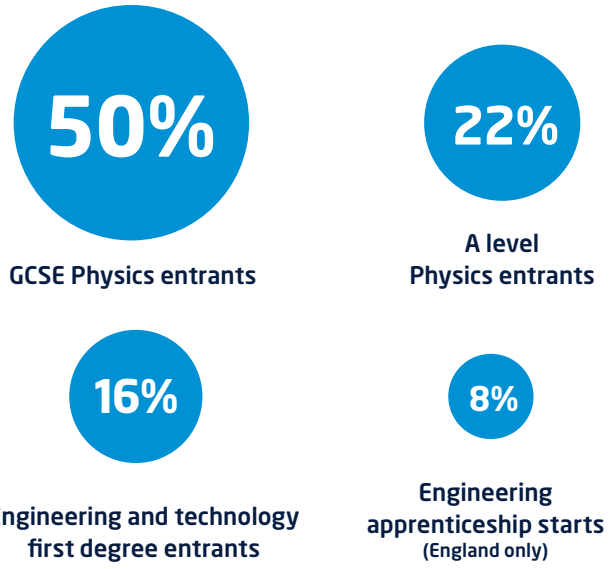
This disparity is largely a consequence of the rates of female participation in the engineering educational pipeline. Girls perform better academically in most GCSE and A level STEM subjects than boys and are more likely to progress into higher education generally; yet relatively few decide to study STEM at A level and even fewer progress onto engineering apprenticeships or degrees.

Existing studies suggest the low participation of girls in engineering in part reflects gender differences in understanding of and interest in the profession, as well as perceptions of self-efficacy and identity. Among the young people we surveyed in our Engineering Brand Monitor (EBM) perceptions of and aspirations to the engineering profession were significantly lower among girls than boys. Girls were less likely to feel they could become an engineer if they wanted to; to think that being an engineer would fit well with who they are; or to consider a career in engineering. They were also more likely to describe the profession as 'too complicated or difficult', 'dirty, greasy or messy' and a 'career for men' than boys. Strikingly, many of these differences were observed among children as young as 7, suggesting that such perceptions and aspirations are formulated at an early age, well before young people make key decisions about their educational choices.

For those who continue their STEM studies there are gender differences in the career paths they follow. Six months after graduating, male engineering and technology graduates are more likely to go on to work in an engineering-related role or find employment in the engineering sector than their female counterparts. Likewise, issues of retention and pay gaps are evident between women and men working in engineering occupations.

These findings clearly show more work is needed to inform young people, especially girls, about what a career in engineering can entail and to improve the image of the profession. Not only are there social justice reasons for encouraging greater gender parity in engineering, there is a compelling business case for a more representative workforce. Myriad studies demonstrate that diversity in the workforce yields greater creativity and innovation and improved business performance. And as our latest report, *Engineering UK 2018: The state of engineering*, estimates, every year there is a shortfall of between 37,000 and 59,000 people to meet demand for Level 3+ core engineering skills.[1] It is therefore essential that the engineering and educational communities and government engage with young people – especially girls – to cultivate and sustain their interest in engineering, and demonstrate that it is a profession for everyone.

Proportion female



1 Level 3 qualifications are those that demonstrate completion of secondary school or equivalent and are required to work in qualified/skilled employment or for entry to higher education. Level 3 qualifications include, but are not limited to: GCE A or AS levels, Access to HE diplomas, Welsh Baccalaureate Advanced qualifications (Wales), Level 3 and/or Junior Certificates (Ireland), National 3, NPA or National Certificate Awards (Scotland), and certain technical and vocational qualifications. For more information, please see 'Engineering UK 2018: the state of engineering annex'.

Women in the engineering workforce

It is clear that the gender composition of engineering workers does not reflect that of the overall working population. According to our analysis of the Labour Force Survey, just 12% of those working in engineering occupations in 2016 were women, compared with 47% of the overall UK workforce.

This proportion was even lower when considering just those working in engineering occupations *within the engineering sector*, at 9%. In contrast, 19% of engineers working outside of the sector were women, suggesting that industries not traditionally associated with engineering – such as health, arts, entertainment and recreation – are more successful in attracting female engineers into the workforce.

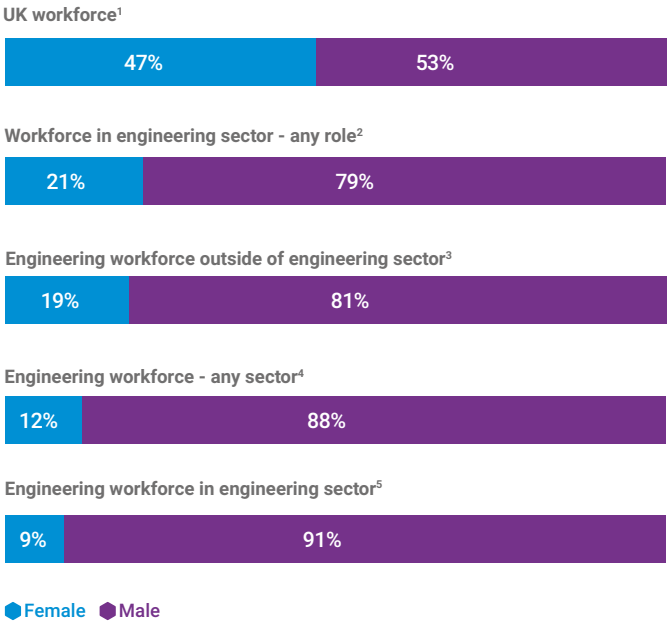
While this briefing considers women in engineering roles and the importance of increasing their representation, it is also evident that women are underrepresented more broadly in engineering companies, making up just 21% of all employees in the sector. This indicates that although the issue is particularly acute among those working in engineering occupations, there is a wider problem of gender underrepresentation in the engineering sector as a whole.

This gender imbalance has clear implications not just for the immediate workforce, but also the extent to which girls are likely to be attracted to the profession in the future. According to a UK study by Microsoft, 70% of girls surveyed said they would feel more confident pursuing STEM careers if they knew men and women were equally employed in these professions,[2] and the lack of visible female role models on girls' career choices is well evidenced in existing literature.[3]

Just 12% of those working in engineering occupations were women compared with 47% of the overall UK workforce.

70% of girls surveyed said they would feel more confident pursuing STEM careers if they knew men and women were equally employed in these professions.

Figure 1 Gender composition of the workforce in 2016 – UK



Source: Office of National Statistics, Labour Force Survey, April to June 2016

Note: This analysis defined the engineering workforce and sector in line with the standard occupational classification (SOC) codes – i.e. jobs – and standard industrial classification (SIC) codes – i.e. industries – considered to relate to engineering, based on the EngineeringUK engineering footprint.

1 - All SOC, all SIC
2 - All SOC, engineering SIC
3 - Engineering SOC, non-engineering SIC
4 - Engineering SOC, all SIC
5 - Engineering SOC, engineering SIC

2 Education Technology. 'Why aren't more girls in the UK studying STEM subjects?', March 2017.
3 e.g. Microsoft. 'How role models are changing the face of STEM in Europe,' April 2018; Young et. al. 'The influence of female role models on women's implicit science cognitions,' Psychology of Women Quarterly, 2013; Hermann et. al. 'The effects of a female role model on academic performance and persistence of women in STEM courses,' Basic and Applied Social Psychology, September 2016.

The business case for gender representation

There is a clear business case for a more representative engineering workforce. Research has consistently shown that a more diverse talent pool brings with it increased creativity and new ideas (essential for an innovative, solutions-based industry[4,5]) as well as enhanced motivation, retention,[6] group problem solving and financial performance.[7] McKinsey's MGI estimated that bridging the UK gender gap in work has the potential to add £150 billion to GDP forecasts by 2025, including by paving the way for more women to work in high-productivity sectors like STEM.[8]

While female underrepresentation has been a longstanding issue for engineering, the need to harness women's considerable potential only grows more acute with the increasing pace of technological advancement. Our estimates, based on *Working Futures 2014-2024*, suggest there is a current annual shortfall of between 37,000 and 59,000 people to meet demand for Level 3+ core engineering skills – and these do not take into account any impact on the supply of engineering workers that the UK's exit from the EU may have.[9] Concerted effort to cultivate female talent and aspiration in engineering is therefore essential if we are to maintain the UK's standing as a world-leading engineering sector, and the considerable economic and social benefits this offers to the nation.

Bridging the UK gender gap in work has the potential to

add £150 billion

to GDP forecasts by 2025.

Cummins' approach to gender balanced recruitment

Stuart Proctor, Recruitment Manager
Cummins

In 2015, we challenged our regional technical groups with increasing the gender diversity of our engineering workforce. Our aim was to exceed the UK engineering average of 8 to 10% women by finding new ways of delivering gender balanced recruitment.

We decided to focus on our student and graduate opportunities – an area where we hoped we could make a big difference quickly. Our approach was two-pronged: we examined our recruitment processes to identify any unconscious biases that could have been impacting our hiring decisions, and we focused our attention on increasing the number of suitably qualified women applying to the business, since this was consistently low.

We quickly concluded that we needed to shift our focus from looking for candidates who could fill business openings immediately, to identifying high calibre individuals who we could develop to meet the future needs of the business. Making this distinction allowed us to be more inclusive in our approach to candidate sourcing.

For example, we looked at the gender split and volume of students graduating from both the 'traditional' engineering degree subjects (mechanical, electrical, automotive, aerospace) and 'associated' STEM degree subjects such as maths, physics and chemistry. It became clear that including associated STEM degree subjects within our candidate searches increased the potential female representation by over 40,000 per year or 800%.

Altering our advertising strategy allowed us to attract a broader candidate pool. The selection process delivered a 50:50 gender mix on graduate offers. The best candidates were hired and in 2016 and 2017 37% were female.

4 Scientific American. 'How diversity makes us smarter', October 2014.
5 Kellog Insight. 'Better decisions through diversity,' October 2010.
6 Royal Academy of Engineering. 'Creating cultures where all engineers thrive,' September 2017.
7 McKinsey and Company. 'Delivery through diversity,' January 2018.
8 McKinsey and Company. 'The power of parity: advancing women's equality in the United Kingdom,' September 2016.
9 EngineeringUK. 'Engineering UK 2018: The state of engineering', February 2018.

Progression along the STEM skills pipeline

Key to addressing the future demand for engineers is encouraging young people to study STEM subjects and pursue engineering-related qualifications. Yet while girls outperform boys in most GCSE STEM subjects and are more likely to progress to higher education generally, relatively few decide to study such subjects at A level and even fewer progress onto engineering apprenticeships or degrees.

Secondary schooling

GCSE take-up and attainment

Differences between boys and girls in subject choice emerge at ages 13 and 14, when they are required to choose their GCSE subjects. While mathematics is compulsory, pupils have some say over the depth of the material they will cover in science, as well as in the non-compulsory subjects they can choose to pursue.[10]

The gender gap among students taking 3 individual science GCSEs has, encouragingly, narrowed in recent years.[11,12] Nevertheless, girls remain underrepresented in many STEM subjects, most notably in engineering (where they comprise 10% of students studying the subject) and computing (20%) – but also design and technology (39%) and ICT (39%).

Strikingly, with the exception of mathematics (where boys do marginally better than girls overall) and physics (where girls and boys are equal), in every selected STEM subject shown in Figure 2, a higher proportion of girls achieve an A*–C grade than boys. While in most cases the differences are relatively small, the attainment gap is particularly pronounced within some subject areas. In engineering, for example, two thirds of girls achieved A*–C grade GCSEs in the academic year 2016 to 2017, compared with 42% of boys.

A level take-up and attainment

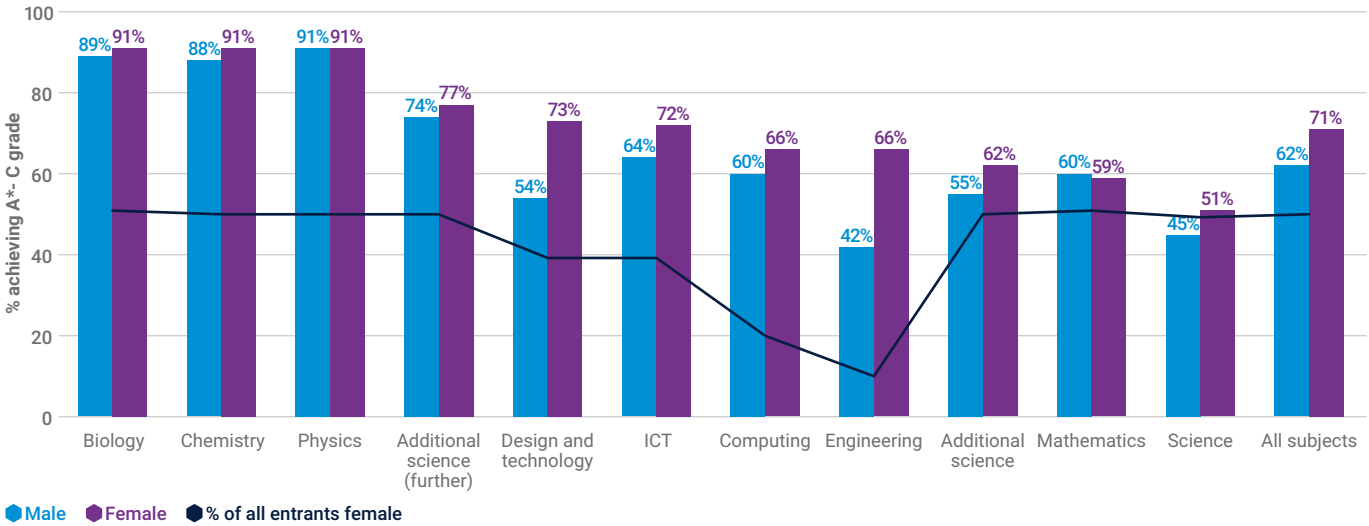
Given that girls outperform boys in almost every STEM subject at GCSE, it is surprising that the gender STEM participation gap continues to widen at A level. Age 16 is the point at which the largest drop off in the number of girls studying core STEM subjects occurs, despite girls making up the majority of all A level entries.[13]

In the academic year 2016 to 2017, boys comprised the majority of A level entries in every STEM subject except biology (38% boys) and chemistry (49%) (Figure 3). This gender imbalance was most marked in computing (90% boys), physics (78%) and further mathematics (72%).

For a number of these subjects the gender imbalance appears to have worsened over time. For example, in computing, total entries increased by 118% over five years, but the proportion of girls increased by only 2 percentage points. Similarly, in further mathematics, overall entries went up by 22% but girls' entries fell by 0.9 percentage points.

The overall gender attainment gap in STEM subjects apparent at GCSE is also observed at A level. Among those who decided to pursue STEM subjects in the academic year 2016 to 2017, 79% of girls attained A levels graded A*–C, compared with 75% of boys. This attainment gap has been almost constant since at least 2014.

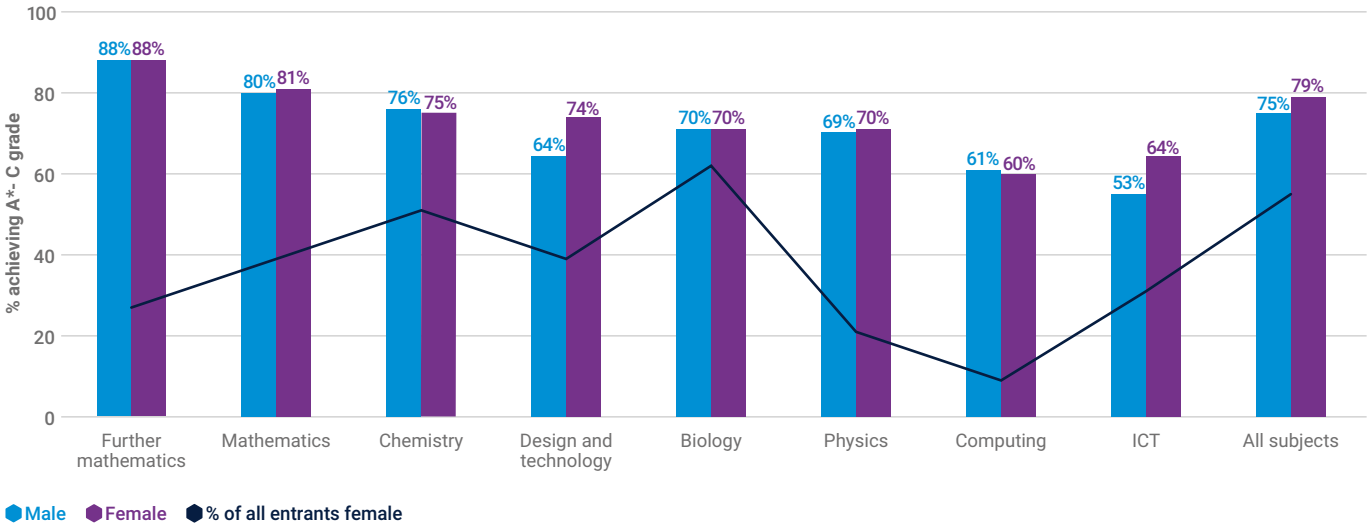
Figure 2 Attainment and take-up of selected STEM subjects at GCSE level in the academic year 2016 to 2017, by gender – UK



Source: JCQ, 2016/17

10 Not all schools give pupils the opportunity to choose – some do not offer 3 individual science GCSEs, so these students are limited to studying either double or core, for example.
11 BIS. 'Professor John Perkins' Review of Engineering Skills', November 2013.
12 WISE. 'Analysis of GCSE STEM entries and results', 2017.
13 WISE. 'The STEM education pipeline', 2017.

Figure 3 Attainment and take-up of selected STEM subjects at A level in the academic year 2016 to 2017, by gender – UK



Source: JCQ, 2016/17

With the exception of mathematics and physics, in every selected STEM subject at GCSE level, a higher proportion of girls achieve an A*–C grade than boys.

Higher education

The subject choices girls make in secondary schooling have a clear effect on their subsequent representation in engineering within higher education, as most undergraduate engineering courses require applicants to have undertaken mathematics at A level, and many require or prefer an A level in physics.

In recognition of the barriers A level physics and mathematics entry requirements may present to those who do not hold these qualifications, some universities such as University College London (UCL) have opted to drop these as entry requirements into some engineering courses – or to offer access or foundation degrees – in an effort to widen participation.[14]

Although consistently more women progress into higher education than men – comprising 56% of first degree entrants in the academic year 2015 to 2016 – just 16% of first degree entrants into engineering and technology were female. This made it a subject area with one of the lowest proportions of first degree entrants who were women, second only to computer science.

Examining this further by discipline reveals that, in the academic year 2015 to 2016, female underrepresentation at first degree level was most severe in mechanical (10%) and aerospace engineering (12%). However, encouragingly, both disciplines have seen a significant increase in the number of female qualifiers (rising by 46% and 47% respectively over the five years leading up to the academic year 2015 to 2016).

In 2015/16, just 16% of first degree entrants into engineering and technology were female. This makes it a subject area with one of the lowest proportions of first degree entrants who were women, second only to computer science.

14 Evening Standard. 'Women push for places on UCL engineering course after it dropped need for physics and maths A level,' April 2015.

Figure 4 Take-up of selected engineering degree courses in the academic year 2015 to 2016, by gender and degree level – UK

Engineering discipline	First degree undergraduate: % female	Postgraduate taught: % female	Postgraduate research: % female
Aerospace engineering	12%	15%	18%
Chemical, process and energy engineering	27%	30%	33%
Civil engineering	18%	31%	33%
Electronic and electrical engineering	13%	24%	20%
General engineering	19%	23%	25%
Mechanical engineering	10%	13%	16%
Naval architecture	16%	9%	9%
Production and manufacturing engineering	22%	31%	21%
Engineering and technology	**16%**	**25%**	**25%**

Source: HESA student record 2015/16

Women are slightly better represented at postgraduate level, making up a quarter of both taught and research engineering and technology students in the academic year 2015 to 2016. Again, the underrepresentation of women was particularly acute in mechanical engineering (13% of taught postgraduate students and 16% of research postgraduate students), aerospace engineering (15% of taught postgraduate students and 18% of research postgraduate) and also naval architecture (9% of taught postgraduate students and 9% of research postgraduate students).

Apprenticeships

As shown in **Figure 5**, female underrepresentation is even more acute among apprentices. While women comprised more than half of all apprenticeships starts in England (53%) and 61% of those in Wales in the academic year 2016 to 2017, under one in ten of those on engineering-related apprenticeships were female (8% and 9%, respectively). At just 3%, the underrepresentation of women was even more marked in Scotland, though it is also apparent there was a gender imbalance among apprentices in the nation more broadly. This was also the case for Northern Ireland, where women made up only 30% of apprentices generally, but represented 11% of those relating to engineering.

While women comprised the majority of apprenticeships starts in England and Wales, under one in ten of those on engineering-related apprenticeships were female.

15 Level 2 and 3 figures for Northern Ireland relate to the number of participants on the programme/provision in 2016/17 rather than starts. Those covering level 4+ apprenticeships refer to the number of enrolments in further education in 2016/17; the ratio of enrolments to individual starts is 1.06. The definition of engineering-related subjects used here is the same as for England.

Figure 5 Apprenticeship programme starts in engineering-related and all sector subject areas in England, Northern Ireland,[15] Scotland and Wales in the academic year 2016 to 2017 (all levels), total and by gender

UK nation	Sector subject grouping	2016/2017 starts	Of which: starts by women	Percentage starts by women	1-year change in percentage of starts by women (pp)
England	Engineering-related	111,550	9,040	8%	0
	All sector subject areas	494,900	264,400	53%	0.7
Northern Ireland	Engineering-related	4,889	531	11%	1.7
	All sector subject areas	8,590	2,544	30%	-3.4
Scotland	Engineering-related	9,149	311	3%	-0.4
	All sector subject areas	26,262	10,440	40%	-0.9
Wales	Engineering-related	4,765	450	9%	-1.2
	All sector subject areas	24,115	14,675	61%	1.8

Source: Education and Skills Funding Agency 2016/17; Northern Ireland Department for the Economy 2016/17; Skills Development Scotland 2016/17; Statistics for Wales 2016/17

Barriers to gender representation

Existing research into why many girls decide not to continue in their STEM studies or pursue engineering careers shows the reasons are multifaceted and complex. The reality is that women are not a homogenous group, and their identities intersect with multiple personal and contextual factors as they progress through education and make career choices. Barriers to pursuing STEM education and engineering careers – those relating to a lack of knowledge of engineering, for example – may be common to both genders and point to the importance of stepping up engagement with all young people.

Nevertheless, there is compelling evidence that gendered norms and stereotypes associated with engineering can have an effect on girls' self-efficacy and identity, which can in turn influence their subject and career choices. From the toys girls are encouraged to play with[16] to the words their parents use to describe the world to them,[17] the representations of science they see in popular media[18] to how their ability is assessed by teachers,[19] a range of research shows how deep-rooted gender bias impacts on girls' everyday lives and the effect it can have on their confidence, self-perceptions, and aspirations.

Evidence from the Engineering Brand Monitor

Findings from our annual Engineering Brand Monitor (EBM), a nationally representative survey of young people, teachers, and parents into their perceptions and understanding of engineering highlight gender differences in knowledge, self-efficacy and identity.

About the data

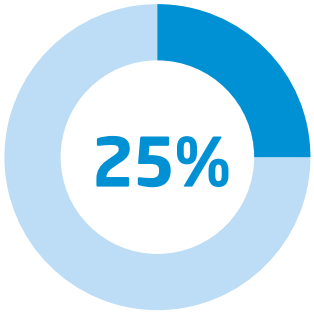
The Engineering Brand Monitor (EBM), carried out by IFF Research Ltd. on behalf of EngineeringUK, is one of the largest surveys into public perceptions of engineers and engineering and on STEM school subjects and careers in the UK.

This briefing outlines findings from our 2017 survey of more than 2,500 young people and 2,000 adults across the UK. To ensure the survey was nationally representative, sampling was spread across the UK and further weighting applied across key demographic attributes.

16 Research by the Institution for Engineering and Technology (IET) found that toys with a science, technology, engineering and maths (STEM) focus were three times as likely to be targeted at boys than girls.
17 Findings show boys receive more early exposure to spatial language – the words and ways people describe things, people and places – than girls and, by default, using it more as they grow. This can be a predictor of success in STEM (Source: Pruden, S. M., & Levine, S. C. 'Parents' spatial language mediates a sex difference in preschoolers' spatial language use', Psychological Science', 2017).
18 ASPIRES. Moote, J., & Archer, L. 'Failing to deliver? Exploring the current status of career education provision in England', Research Papers in Education, 2017.
19 Unesco. 'Cracking the code: girls' education in STEM, 2017'.

Views and consideration of engineering careers

These results show that many girls have lower perceptions of the profession than their male peers, with just 42% of girls aged 11 to 19 viewing engineering positively and a third seeing it as a desirable profession, compared with 66% and 54% of their male peers, respectively. Notably, gender differences in views and desirability of technology and science careers were far narrower, suggesting engineering faces additional challenges beyond those documented in STEM (Figure 6).[20]

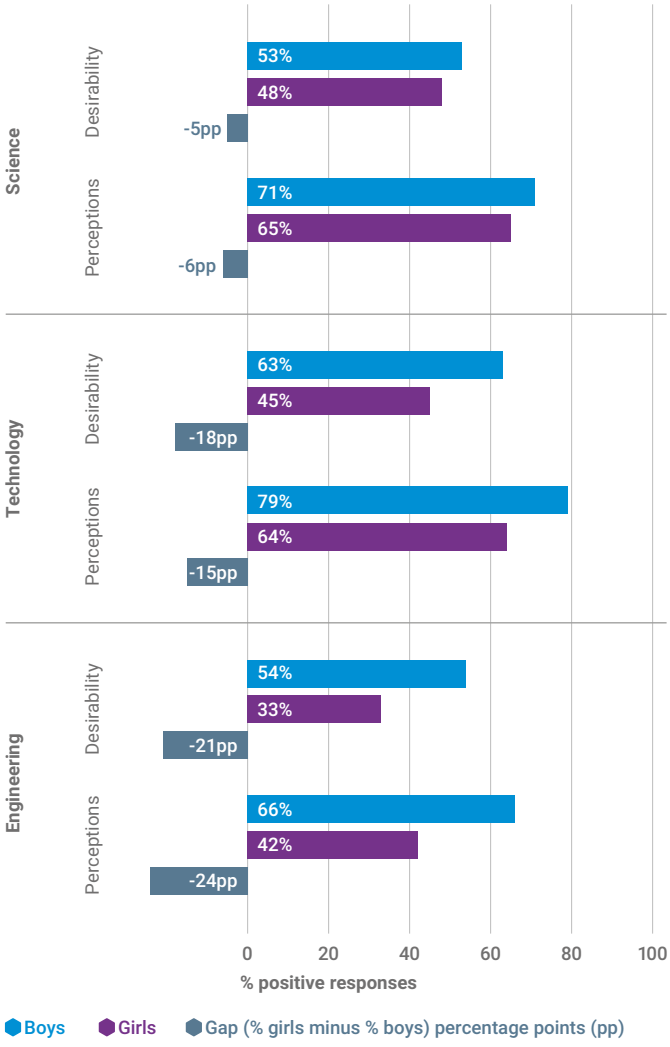


Just 25% of girls aged 16 to 19 said that they would ever consider a career in engineering.

It is also evident that many girls simply do not have engineering careers on their radar. In fact, in every age group, under two in five girls we surveyed reported they had ever thought about becoming an engineer, compared with the majority of boys (Figure 7).

Perhaps more concerning is that when asked whether they would ever consider a career in engineering, girls were far less likely to respond positively than boys. Among those aged 11 to 14, 70% of boys reported that they would consider a career in engineering, 1.5 times the proportion of girls reporting the same (46%). Though the proportion was lower among older respondents of both genders, the difference was starker among girls than boys – just 25% of girls aged 16 to 19 said that they would ever consider a career in engineering – underscoring the importance of earlier intervention.

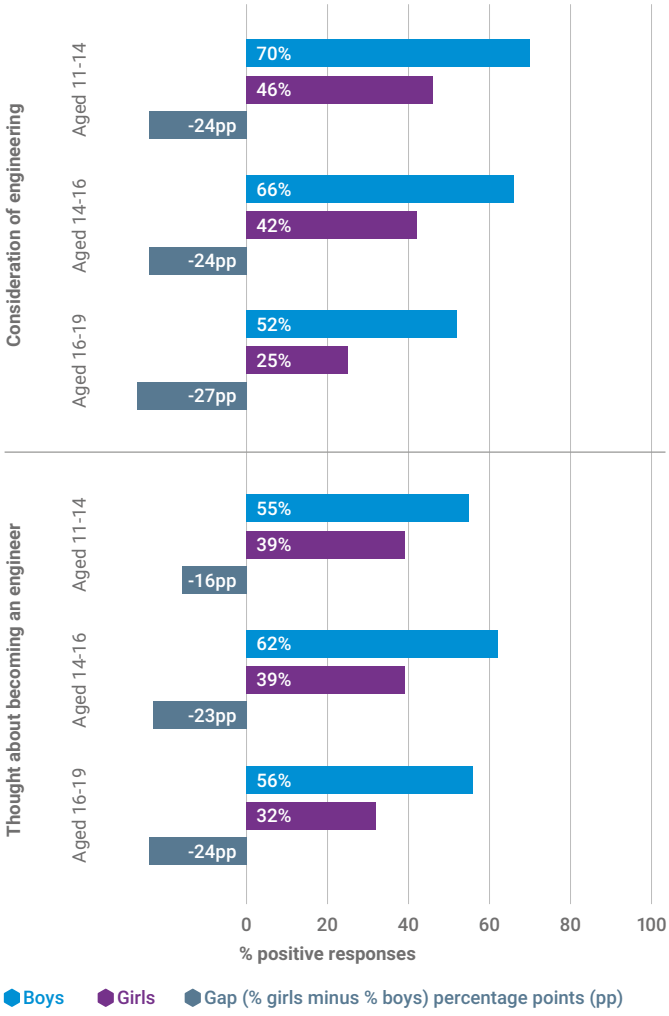
Figure 6 Positive perceptions and desirability of STEM careers among young people aged 11 to 19 in 2017, by gender – UK



Source: EngineeringUK's Engineering Brand Monitor 2017
Q: How desirable do you believe a career in the following areas (science, technology, engineering) to be? [% selecting '4- Quite desirable' or '5-Very desirable']
Q: How positive or negative is your view of the following areas: science, technology, engineering? [% selecting 'Quite desirable' or 'Very desirable']

20 Gender gaps in perceptions were not statistically significant for science, and 9 percentage points narrower for technology than for engineering. Even though less than half of girls saw either as desirable, the majority reported positive perceptions of both (65% and 64% respectively).

Figure 7 Consideration of a career in engineering and thought given to becoming an engineer among young people aged 11 to 19 in 2017, by age group and gender – UK



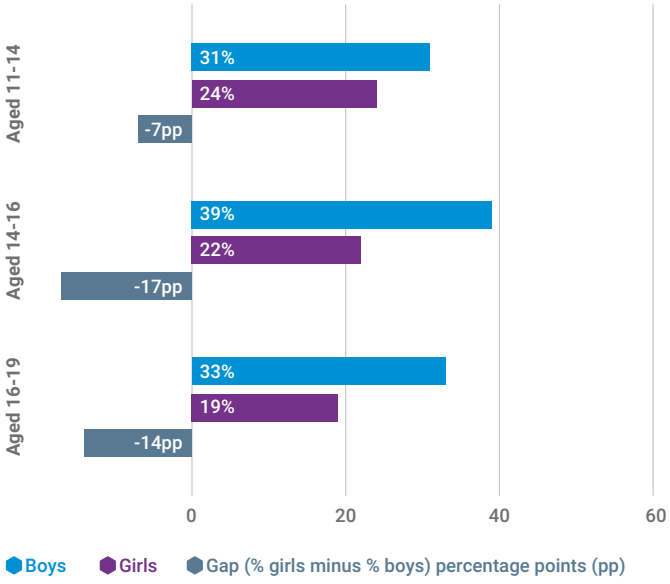
Source: EngineeringUK's Engineering Brand Monitor 2017
Q: Do you think you would ever consider a career in engineering? [% selecting 'Yes']
Q: Have you ever thought about becoming an engineer? [% selecting 'Yes']

Asked how much they knew about what engineers did, 48% of girls surveyed reported they knew 'almost nothing' or just 'a little' compared with 31% of their male peers.

Knowledge of engineering

While knowledge of engineering as a profession was limited across both genders, we found that girls' understanding lagged behind that of boys in every age group surveyed (Figure 8). Asked how much they knew about what engineers did, 48% of girls reported they knew 'almost nothing' or just 'a little' compared with 31% of their male peers. This gender gap was largest among the 14 to 16 age group, when young people were making key decisions about subject choices and educational pathways.

Figure 8 Knowledge of engineering careers among young people aged 11 to 19 in 2017, by age group and gender – UK



Source: EngineeringUK's Engineering Brand Monitor 2017
Q: How much do you know about what people working in the following areas do (science, technology, engineering)? [% selecting '4-Know quite a lot' or '5-Know a lot']

When asked whether they thought they could become an engineer if they wanted to, just 60% of girls aged 11-14 said yes compared with 72% of boys.

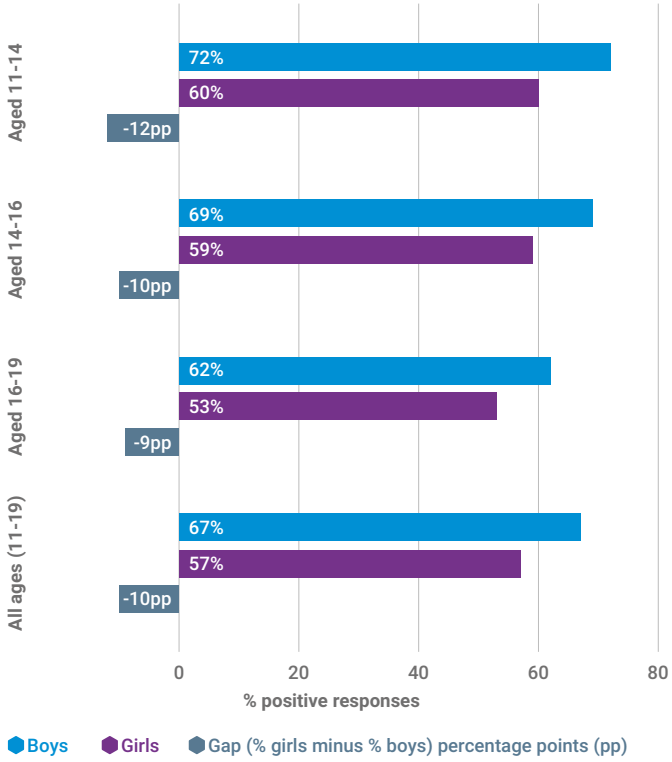
Our findings also suggest girls often do not have a full understanding of the excitement and variety a career in engineering can offer, or of the potential contribution they can make as an engineer. For example, there is a clear disconnect between what many girls believe the engineering profession involves and the things they say are important to them when deciding on a professional career. Asked what factors were important to them in considering a career, girls were more likely than boys to value making a difference/having an impact (+10 percentage points), being valued (+8 percentage points), and opportunities to be creative (+9 percentage points) – and less likely to recognise an engineering career as an opportunity to fulfil these aspirations.

Self-efficacy and identity

Beyond a lack of knowledge, it is apparent that the girls we surveyed were less likely to see engineering as consistent with their own identity and more likely to hold lower perceptions of self-efficacy. When asked whether they thought they could become an engineer if they wanted to, just 60% of girls aged 11 to 14 said yes compared with 72% of boys. Among those aged 16 to 19, this was even lower, at 53% (**Figure 9**). Such findings are striking, given that girls on average outperform boys in most STEM subjects at GCSE and A level.

Our survey also found that across all age groups, girls were significantly less likely than boys to say that being an engineer would 'fit well with who they are'. Among those aged 16 to 19, the share of boys who thought the profession would 'fit well with who they are' (37%) was about three times as high as that of girls of the same age (12%). This resonates with other studies that show that fears of not being 'clever enough'[21] to do well in STEM subjects and careers, being 'the only girl in the class' or having to change their personality in order to 'fit in' can represent significant barriers for girls in STEM.[22]

Figure 9 Perceptions of possibility of becoming an engineer if they wanted to among young people aged 11 to 19 in 2017, by age group and gender – UK



Source: EngineeringUK's Engineering Brand Monitor 2017
Q: And if you wanted to, do you think you could become an engineer? [% selecting 'Yes, probably' or 'Yes, definitely']

21 Archer, L. and J. DeWitt. 'Understanding Young People's Science Aspirations', Routledge, 2017.
22 Institute of Physics. 'Opening doors – A guide to good practice in countering gender stereotyping in schools', October 2015.

Perceptions of the profession

Many of the reasons girls cite for their disinterest in engineering clearly reflect a narrow view of what a career in the industry can offer, alongside a belief that it is a masculine profession not in line with their perceived abilities or identity.

Of those reporting engineering to be an undesirable profession, a higher proportion of girls than boys saw it as being too complicated or difficult (26% compared with 18% of boys); a career for men (18% compared with 1%); dirty, greasy or messy (28% compared with 24%); or boring (28% compared with 24%).

Significantly, these attitudinal differences were apparent among even the youngest of children we surveyed, suggesting that girls may rule out a career in engineering even before they have academic experiences of it or associated subjects. Twice as many girls as boys aged 7 to 11 in the EBM described engineering as 'too complicated/difficult' (43% compared with 21%), and nearly four times as many thought of it as 'boring' (19% compared with 5%).

Access to careers advice

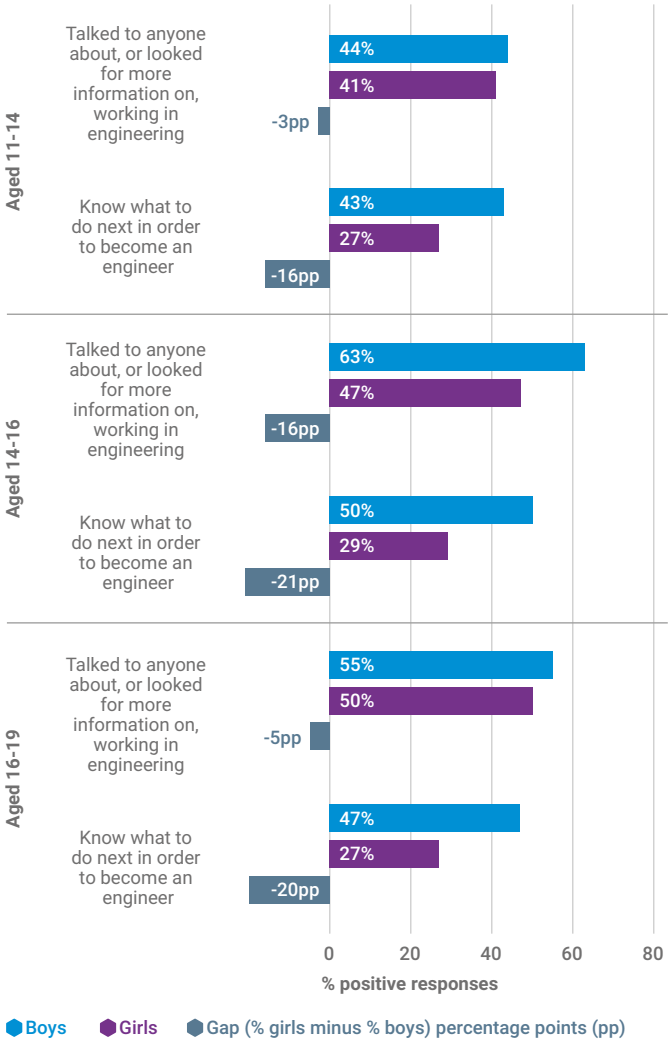
Even for girls who might be inclined to study engineering, it is clear that they are less aware of the pathways to do so than their male peers. As shown in **Figure 10**, just 28% of girls aged 11 to 19 agreed that they knew what to do next to become an engineer, compared with 46% of boys – with the widest gender gap among the 14 to 16 age group, at 21 percentage points.

Moreover, not only were girls' self-reported knowledge of engineering careers and how to pursue them lower than boys', they were also less likely to seek careers advice from others: just 46% of girls surveyed had sought careers advice, compared with 53% of boys. The gap was particularly pronounced among 14 to 16 year olds; in this age group, over a third more boys who thought about becoming engineers had talked about this to others than their female peers (63% compared with 47%).

These findings resonate with wider research into careers provision in England, which found that girls were less likely to receive careers education than their male peers, and were therefore significantly disadvantaged in a system often delivered via self-referral.[23]

Girls were not only less knowledgeable about engineering and how to become an engineer, but also less likely to seek careers advice from others.

Figure 10 Knowledge of what to do next to become an engineer and talking to anyone about, or looking for more information on, working in engineering among young people aged 11 to 19 in 2017,[24] by age group and gender – UK



Source: EngineeringUK's Engineering Brand Monitor 2017
Q: How much do you agree or disagree with the following statement: I know what to do next in order to become an engineer? [% selecting '4- Agree a little' or '5-Agree a lot']
Q: And have you talked to anyone about, or looked for more information on, working in engineering? [% who have 'thought about becoming an engineer before' selecting 'Yes']

23 Moote, J., & Archer, L. 'Failing to deliver? Exploring the current status of career education provision in England', Research Papers in Education, 2017.
24 For this question, the respondent base is young people aged 11-19 who reported having thought about becoming an engineer in a previous question.

UCL's 50:50 engineering engagement strategy

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In 2014, UCL Engineering introduced our 50:50 Engineering Engagement Strategy to guide our approach to pre-19 engineering engagement. Under this strategy, we redesigned activities and developed new programmes to demystify engineering, enabling young people from all walks of life to defy stereotypical views of who can become an engineer and what this entails.

Implemented across our 134 STEM programmes, to date the strategy annually connects over 6,000 young people and a network of 529 schools with 623 UCL Engineering staff and students. It has received national and international recognition from government, academia, industry, the EU Commission and UNESCO.

At the strategy's core is the aim to strengthen and diversify the engineering workforce, encouraging young people from all backgrounds to consider engineering career pathways. Requiring 50% participation of girls across all our engagement programmes was never just about getting a 50:50 gender balance. It was – and still is – about sending a strong message in the classroom, at home and to society about the invisible barriers affecting confidence, self-efficacy and career choices.

Our programmes enable and inspire young people to participate in authentic engineering projects through an experimental approach. These interventions focus on sustained, meaningful engagement, building on pupils' engineering experiences over time, and span the entirety of primary and secondary education, offering girls and boys as young as age 4 an equal opportunity to experience engineering.

We also recognise that high quality classroom education relies on excellent teachers and the learning they encourage. To that end, via CPD courses, tailored curriculum-based resources and trained engineering students, we support teachers to be confident and innovative when teaching STEM, creating authentic learning experiences and helping pupils develop relevant skills.

Furthermore, our engineering students share with pupils their experiences and differing personal pathways into engineering to inspire and instil the same passion in them. They are relatable role models, representing engineers from different gender, race, ethnicity, ability and socio-economic backgrounds. This enables young people to begin establishing a network of social contacts with real engineers close to their age, and to feel our programmes are inherently inclusive and "for them".

As a result, our 50:50 Strategy has created a real step change in diversity, with girls' participation rates in our programmes seeing an increase from 19% to 63% in under a year, and a similar rise for BAME pupils.

Our survey found that knowledge of engineering and confidence in providing relevant careers advice was limited among many parents and teachers.

The role of key influencers

Key influencers – parents and teachers in particular – play an important role in both engaging and informing young people in STEM and in shaping their expectations and self-belief. It is widely acknowledged that active encouragement in school and at home plays a vital role in sustaining girls' interest in STEM education and careers.[25] Conversely, the home and school environment can act to replicate the ingrained gender stereotypes and unconscious biases that exist in wider society, even when these environments are generally supportive of gender equality.

It is evident from our results that young people value guidance from their parents and teachers on their educational and career choices, with 70% of 11 to 14 year olds describing parents/carers as key sources of career advice, and two thirds saying so of teachers. Yet we found knowledge of engineering and confidence in providing relevant careers advice limited among many parents and teachers. Just 31% of parents surveyed indicated they knew 'quite a lot' or 'a lot' about what engineers did and only 36% expressed confidence in giving advice to their children about a career in engineering. While the proportions of STEM secondary school teachers reporting knowledge and confidence were considerably higher, there remains room for improvement: around 1 in 5 teachers reported they knew 'little' or 'almost nothing' about engineering (20%) or lacked confidence in giving advice about careers in engineering (22%). This has a clear bearing on their ability to support their children in making informed choices.

There is also evidence to suggest that some parents and teachers, rather than working to encourage girls to pursue STEM or careers in engineering, in fact hold attitudes that may inhibit them. Parents were less likely to say they would recommend an engineering career to their female children than their male children (80% compared with 84%), for example. Similarly, recent research has suggested that 29% of male teachers think STEM careers are more for boys than girls, and 24% of all teachers surveyed do not feel confident or do not know that job opportunities exist for girls going into STEM careers.[26] Such findings highlight a need to dispel myths and stereotypes about the profession among the wider public – not just among young people.

70% of 11 to 14 year olds described parents and carers as key sources of career advice

Looking beyond education

It is clear that if girls are to have a full understanding of the excitement and variety a career in engineering can offer, they require greater exposure to real life applications of the discipline, access to high quality careers advice and guidance, and well-informed support from parents and teachers. The engineering community must actively work to challenge the masculine stereotypes of the profession and signal equally to both girls and boys that they belong and can succeed in this field.

Yet cultivating female talent and aspiration is only one aspect of tackling gender underrepresentation in the engineering workforce. There is significant evidence to suggest there are also challenges for women in the profession. This starts at the point of entry: of engineering and technology graduates who found employment six months after graduation, 36% of women were in roles that were neither engineering-related nor within the sector, compared with 30% of male engineering and technology graduates.[27] Gender pay gaps are evident among those working in engineering occupations, with the average full-time salary higher for women than men in only two of 36 occupational groups for which this data was available.[28] Retention is also an issue for many, with nearly half of all female graduates leaving the profession within a few years of gaining an engineering degree.[29] Research undertaken by the Institution of Mechanical Engineers into this attrition has highlighted issues relating to equal treatment, recognition and promotion, suggesting there is much to be done to make the engineering workplace an inclusive and equitable environment.[30]

If we are to meet the future engineering skills demand, it is important that the engineering community not only inspires young girls to become engineers, but also works to support the careers of women once in the industry.

25 e.g. Microsoft. 'Why Europe's girls aren't studying STEM', 2017.
26 British Gas and Catherine O'Kelly. 'Teachers desperately need support from Britain's businesses to close the STEM skills gap', August 2017.
27 EngineeringUK. 'Engineering UK 2018: The state of engineering', February 2018.
28 EngineeringUK. 'Engineering UK 2018: The state of engineering', February 2018. Analysis relates to annual gross pay for full time employees working in core engineering
29 Institution of Mechanical Engineers. 'Stay or go? The experience of female engineers in early career', July 2017.
30 Ibid

Widening routes into engineering

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It is apparent from this briefing that changing societal attitudes is key if we are to tackle gender underrepresentation in engineering and encourage more young people of both genders to aspire to the profession. Our community can and should do much more in this area. In recognition of this, in January 2018 the Royal Academy of Engineering launched *This is Engineering*, a multi-year campaign aimed at improving the image of engineering among young people aged 13 to 18. The impact on perceptions of engineering among young people will not be known for some years, but we hope it serves to illustrate to them the diversity of engineering careers.

However, the current educational system is a key barrier to raising perceptions and understanding of – and aspirations to – the profession. The siloed way in which subjects are taught inhibits students from developing a full understanding of how engineering relates to everyday life and the other subjects they study, and the emphasis on exam results and a requirement to specialise early discourages students from discovery-based learning and keeping their future career options open. If we are to make engineering a diverse and inclusive profession reflective of wider society, the education system – from schools through to adult learning – needs to change to widen routes into engineering.

A broader, interwoven curriculum

Engineering is, at its heart, about solving societal problems and is the ultimate interdisciplinary profession. In addition to the obvious application of science and maths, it requires an integrative style of thinking: an understanding of how people interact, creative thinking and a design mindset to conceptualise a problem and develop solutions.

A broader, interwoven curriculum where students can contextualise theory and problem-solving within the wider world is therefore essential if we are to cultivate the skills necessary for engineering. We also know it can help address gender imbalances in the industry, as female students especially are receptive to concepts that have social value and practical applications.[31]

The way STEM subjects are currently taught in schools, however, is at odds with the open-ended investigative methods used by practising scientists and the design and practice-based approach used by engineers. In fact, today's EBacc is worryingly similar to the school leavers' curriculum of 1904.[32] It does not adequately reflect the world of today, nor equip students with the skills they will need in the world of tomorrow. The insular siloed manner in which subjects are taught furthermore hinders students from developing an understanding of how different subjects interlink, or the possible career opportunities that will arise from them.

Similarly, the way young people are assessed – with an emphasis on exam results – provides a narrow measure of success that diminishes a desire for discovery-based learning. Current accountability measures such as Progress 8 and Attainment 8, designed to encourage schools to offer a broad and balanced curriculum to students, instead do the opposite, actively disincentivising the promotion of creative and technical subjects.

Later specialisation

In most UK school systems, young people are required to specialise in arts and humanities or sciences. This, combined with the fact that engineering is all too often invisible in the curriculum and poorly understood by young people, teachers and parents alike, means that for many the route is closed to engineering before they have a full understanding of what the profession is.

If students were able to study a larger number, and wider variety, of subjects for longer, this would enable them to make more considered and informed educational and career choices. This is likely to be of particular benefit to the female engineering pipeline, as evidence shows that women tend to make career choices later. Students would also be more likely to study a combination of subjects at which they excel, whether or not they appear connected or superficially complementary – which we know is a barrier for many girls in studying STEM.

31 Institute of Physics. 'Girls in the Physics classroom: a review of the research on girls' participation in physics,' June 2006.
32 Edge Foundation. '14-19 Education: A new Baccalaureate.'

A true baccalaureate-type approach would furthermore provide a more rounded and rewarding education for all. Those focused on studying the arts would develop a greater degree of scientific and engineering literacy and numeracy, as well as a range of skills that will be useful in many areas of life. Likewise, those focused on the sciences would have greater exposure to design and creativity, producing more well-rounded engineers.

Lifelong learning

Rethinking the schooling system would empower more students, and especially more female students, to develop an interest in engineering and subsequently enter the profession. We should, however, also be mindful of the large untapped reserve of talent among the existing workforce.

While a wide range of entry points into engineering exist– both academic or vocational – access could be improved so that there are flexible and convenient education and training options for the adult learner. This would particularly empower women to enter the profession, who usually undertake the majority of caring responsibilities, and therefore are not always able to commit to a full-time course or to continue on in their current profession.

There are already some opportunities for adults to enter engineering education. For example, some universities provide foundation degree courses for those whose A level subject choices does not allow direct entry into a BEng or MEng course: successful completion of the foundation year usually guarantees entry to a full engineering degree course. Similarly, postgraduate conversion courses are available to those who have already completed a degree in a related numerate subject to transition into an engineering career.

Such courses are a positive initial move towards broadening adult access to the engineering profession, but their delivery could be further improved. To be truly accessible, they need to be offered at more universities to avoid a postcode lottery of provision and on a part-time or flexible basis to accommodate each student's circumstances.

The expansion of apprenticeship provision offers another progressive route into the engineering profession that allows individuals to earn whilst they learn and avoid the accumulation of debt. However, as this briefing highlights, women currently make up a very small proportion of engineering apprenticeship starts, in part due to an inadequate understanding of engineering or poor school careers advice.

Opportunities for engineers who have taken a career break to return to the profession are also welcome: there are far too many women who do not return to engineering after taking maternity leave. 'Returnships' offer those who have taken an extended break an opportunity to refresh their technical and transferable skills, and to explore a new area of expertise. The STEM Returners project, for example, has been created by the Institute of Marine, Engineering, Science and Technology and Women's Engineering Society, with the aim of helping employers recruit and develop the best available talent and supporting qualified and experienced candidates to re-start their career after a break.

Harnessing the talent pool

To address the skills shortage in engineering, we must harness the talent pool of women: both those currently in the workplace and the future female workforce. This endeavour must be multifaceted, aimed at changing perceptions of engineering as well as facilitating access to engineering education. It is ultimately up to individuals to decide whether they want to pursue a career in engineering – but we must make sure their entry into the profession is as easy as possible.

The potential for STEM engagement activity to inspire the next generation of female engineers

STEM engagement activities can make a real difference to increasing rates of participation among young people and can serve as an influential tool to inspire the next generation of female engineers. EngineeringUK leads two engagement programmes – Big Bang and Tomorrow's Engineers – which aim to inspire young people, improve their perceptions and knowledge of engineering careers and to inform them about the educational pathways available for pursuing them.

Participation rates in EngineeringUK's educational programmes among girls are, encouragingly, on par with those of boys (50:50 representation). An examination of key evaluation indicators from the academic year 2017 to 2018 suggests that these engagement activities are largely successful in improving girls' knowledge and perceptions:

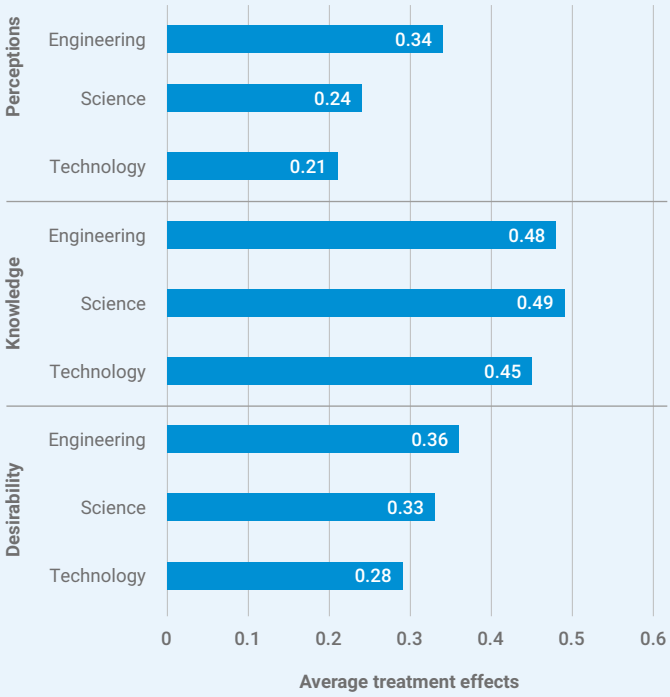
- 92% of female participants reported enjoying the event
- 92% agreed that the event showed them that engineering is suitable for both boys and girls
- 72% said the event made them feel that a job in engineering would be interesting
- 57% said the event improved their knowledge about what to do next in order to become an engineer

Figure 11 shows there is a positive effect of participation on a number of key evaluation indicators, particularly in terms of increasing young people's knowledge of what people in science, technology and engineering jobs do. A statistically significant and positive effect on perceptions of engineering was identified for both boys and girls, but for girls this is particularly pronounced, suggesting that STEM engagement activities can go some way to inspiring the next generation of girls to become engineers.[33]

Results from EngineeringUK's evaluation research suggest that certain aspects of these STEM engagement activities are especially effective. Young people who met an engineer held more positive views of engineering (81% compared with 64% who did not meet an engineer), and young people who spoke to someone about a career in STEM were more likely to see a career in engineering as desirable (71% compared with 53%) and to state that they had good knowledge of the next steps they need to take to pursue such a career (73% compared with 54%).

Other results suggest that STEM engagement and outreach is most impactful when participation is sustained over a long period of time, implying that attempts to increase the representation of girls in STEM would be best achieved with educational programmes and activities designed to involve prolonged or repeated engagement.

Figure 11 Effects of participation in EngineeringUK's STEM engagement activities on perceptions, knowledge and desirability of careers in science, technology and engineering among young people aged 11 to 14 (ATE)[34] – UK



Source: EngineeringUK's Engineering Brand Monitor & EngineeringUK's evaluation data

Note: These average treatment effects (ATE) represent the estimated influence of taking part in EngineeringUK's activities on the likelihood of young people providing a positive response to each of the three indicators considered (e.g. reporting having a positive view of engineering as compared to a negative view). These were estimated using propensity score matching with variables for region, country, age and gender. All ATEs are statistically significant at the 95% level.

33 The results presented here refer to young people aged 11 to 14 who took part in EngineeringUK's activities during 2017/18 (TE) (N=7,166) compared with the same age group in the 2017 Engineering Brand Monitor (EBM) (N=715).

34 A detailed analysis of effectiveness has been conducted using the method of propensity score matching (PSM), the purpose of which is to facilitate a causal interpretation of the results of evaluation. The approach is used with non-experimental data to match individuals in the 'treated' and 'control' samples (TE and EBM, respectively) to account for the absence of random group assignment and thereby minimise selection bias. Application of the method results in an average treatment effect (ATE) which, in this context, is a numerical estimate of the extent to which participation in EngineeringUK's STEM engagement activities has an effect on the outcome under consideration.

Who we are

Established in 2001, EngineeringUK is a not-for-profit organisation, funded predominantly via the professional registration fees of individual engineers, as well as the support of a range of businesses, trusts and foundations, and a corporate membership scheme.

We work locally, regionally and nationally with a wide range of organisations across business and industry, education, professional institutions and the third sector to understand the engineering skills required by engineering companies and in the wider economy, and work in partnership to develop and promote effective initiatives to inspire young people to consider a career in engineering.

Driven by data

We base everything we do on evidence and we share our analysis and insight widely. Our flagship publication *Engineering UK: The State of Engineering*, published for the 20th time in 2018, is a detailed examination of engineering's economic contribution and the composition of its workforce, as well as the extent to which the supply through the education and training pipeline is likely to meet future needs and demand for engineering skills. Its findings are used widely by the media, policy makers and employers alike. The *Engineering Brand Monitor* establishes the national benchmark for public perceptions of engineers and engineering.

We evaluate all our activity to help ensure our engagements with young people have as much impact as possible. It is through this evaluation that we have identified the degree to which we are winning hearts and changing minds through our programmes, with positive impacts on young people's understanding of engineering, perceptions of a career in it, and the extent to which they view engineering as a career for both boys and girls. And we have learnt that if young people meet an engineer and know they have done so, they come away with higher levels of knowledge of what people working in engineering do and higher levels of perceived desirability of engineering careers.


EngineeringUK