A CALL TO ACTION

Gender and Pathways into Engineering and Technology

CONTEXT SETTING

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Introduction

This is a call to collective action to significantly increase the number of girls on education pathways to engineering and technology at age 18 and explore what needs to change so that engineering and technology careers are desirable and viable for girls from all backgrounds.

We want to build a coalition around this shared action and move from conversation to action – turning ideas into reality. The partnership will collectively map the system, pinpoint opportunities for interventions, develop ideas and push them forward. We will look at opportunities across practice, policy and campaigns and lean into robust evidence, promising practice and new ideas. We will also look at additional research that may need to be done, however we are taking a pragmatic approach and primarily want to identify the actions that can be taken now based on the best available evidence.

EngineeringUK, The Royal Academy of Engineering, Women into Science and Engineering (WISE), The Women's Engineering Society (WES), BCS (The Chartered Institute for IT Professionals) and The Institution for Engineering and Technology (IET) are building the partnership and are inviting contributions from across research, industry, education and outreach.

Whilst we recognise that gender isn't binary, in this paper we focus on girls and young women, as compared with boys and young men, as these are the categories captured in the national data and majority of studies we cite, but our aspiration is that through this work we will uncover principles to ensure STEM is more inclusive and inviting for any individuals who otherwise may feel it's not for them.

In addition, we aim to take intersectionality into account, recognising that some projects may not benefit everyone in a group equally and often benefit more privileged members. Projects for 'girls' or 'boys' may not consider issues around race, religion, sexuality, gender identity, or class, which may have a big impact on the efficacy of a programme.

We have agreed to focus on the outcome of 'education pathways to engineering and technology at age 18' to provide focus and the best chance to move from conversation to action. However, we appreciate that our efforts will only be impactful if attention is also given to other parts of this complex system (e.g., recruitment or retention of women).

The partnership will consider the breadth of the engineering and technology, including digital technology, footprint through the list of Standard Occupational Classification (SOC) codes developed by EngineeringUK, the Engineering Council and Royal Academy of Engineering. The skills and roles in engineering, technology and more specifically digital technology overlap, but the pathways into these areas may vary, for example, pathways into tool manufacturing in an engineering business would likely differ somewhat from those into software engineering in FinTech, we also note that uptake of demographic groups varies across the footprint. While women are under-represented across engineering and technology, there are different influences in these two spaces and therefore potentially different solutions; this will be a consideration throughout the project. This paper considers both areas: for a deeper dive into the technology space please refer to The HG Foundation's rapid review of intervention review evidence; Girls and women in Computer Science (Aug, 2024) and the BCS diversity report 2024: Addressing the under-representation of women in technology (Sept, 2024).

This paper sets out the context to the problem, outlining key factors grouped as societal, educational, and personal, with recognition that these groups will overlap. We then outline some of the evidence and ideas for actions that might make a difference, followed by a brief summary of the policy environment.

This is very much a starting point; we want to build collective wisdom about this context and the various factors influencing girls and young women.

Context

Engineering and technology underpin areas of great national and global need – including improving sustainability and decarbonisation - and jobs are expected to grow faster than other occupations in all areas of the UK between now and 2030, but there is a lack of skilled people to meet this need. For instance, the Climate Change Committee (A Net Zero Workforce) identified that up to 725K new jobs will be needed by 2030 to support the transition to net zero, and we know a significant proportion of these are jobs are in engineering related areas. If we are to ensure effective and innovative solutions for all, it is imperative for the workforce to be diverse and representative.

Unfortunately, we know that there is already a workforce challenge as employers are reporting skills shortages and recruitment challenges. In addition, only 15.7% of the engineering and technology workforce is now made up of women, down from 16.5% last year and contrasting with the 56% of women that make up the rest of the UK workforce (EngineeringUK, 2024). The overall fall of women in engineering and technology is despite a slight increase in the numbers entering and results from an increase in women leaving between the ages of 35 and 44. The overall representation of women is still an increase, albeit a modest one, from 10.5% of women in 2010.

Ultimately, we need more people and more diversity in engineering and technology and part of this is a need to ensure more young people are on educational pathways into these areas. Those from UK minority ethnic groups are also underrepresented (13% vs 15% in overall workforce), as well as disabled people (11% vs 13%) (EngingeeringUK, 2022) and people from a lower socio-economic background (21% vs 29% in overall workforce) (Sutton Trust, 2022). However, the under-representation is much greater for women in the workforce, as stated above, and also in routes into engineering and technology as described below. Women are therefore the focus of this work. However, we appreciate that gender is not an isolated variable. For instance, the ASPIRES research underlines how gender does not operate in isolation but interacts closely with other axes of inequality, such as social class and ethnicity with middle-class girls and girls from white or South Asian backgrounds being much more likely to aspire to STEM careers.

There is a gender imbalance in almost all of the routes typically taken into engineering and technology. It is important to note that although these routes are typical, these qualifications are not always precursors to engineering / tech qualifications or employment[1]:

- Physics A-level - 23% females in 2024 (22% in 2018) in England, Northern Ireland and Wales
- Physics Scottish Higher - 27% females in 2024 (20% in 2018)
- Maths A-level - 37% females in 2024 (39% in 2018) in England, Northern Ireland and Wales
- Maths Scottish Higher - 46% females in 2024 (39% in 2018)
- Computing A-Level – 18% females in 2024 (12% in 2018) in England, Northern Ireland and Wales
- Computer science Scottish Higher - 21% females in 20224 (14% in 2018)
- Design and technology A-Level – 32% females in 2024 (37% in 2018) in England, Northern Ireland and Wales
- Design and manufacturing Scottish Higher – 33% females in 2024 (48% in 2018)
- Physics GCSE - 49% females 2024 (remained the same since 2018) in England, Northern Ireland and Wales
- Physics National 5 - 29% females in 2024 (28% in 2018)
- Computing GCSE - 22% females in 2024 (20% in 2018) in England, Northern Ireland and Wales
- Computer Science National 5 - 23% females in 2024 (20% in 2018)
- Engineering and technology-related vocational qualifications (not including T-Levels) - 10.7% females 2022/23 (10.2% in 2021/22)

[1] We will add some more information/data on international women student participation in the UK v UK domicile

- Engineering and technology-related T-Levels in England – 9% females in 2024 (consistent in 2023)
- Engineering and technology-related apprenticeships in England – 16% females in 2022/23 (14% in 2020/21)
- Engineering and technology degrees across the UK – 19% females in 2024 (20% in 2018/19)

Gender has a very large effect on career aspirations evident from at least the age of 10 at which only 11% of girls aspired to engineering careers, compared to 44% of boys (Aspires, 2020). EngineeringUK's Science Education Tracker, in conjunction with The Royal Society, highlighted that girls are switching off from science, and a gender gap has opened up. There has been a 10%p decline in 11-14 year old girls saying that they are interested in science compared with a 1%p decline in boys between 2019 and 2023. This brings urgency to better understanding and addressing the gender differences in progression through STEM subjects and into engineering and technology careers.

Societal Influences

Gender Stereotypes: Gender stereotyping significantly impacts young people's subject and career choices by shaping their perceptions of what roles are suitable for their gender. From a young age, children are exposed to societal expectations about gender roles, which can limit their subject choices (IOP, 2018) and career aspirations. 70% of young women (18-34s) reported their career choices were restricted due to gender stereotypes (Fawcett Society, 2019). In addition, these perceived gender norms impact on young people's well-being (Children Society, 2020).
We see this bias in society, parents, teachers and peers:

- Although there have been some shifts more recently, there is gender stereotyping in the marketing of children's products, for example in toys (Let Toys Be Toys) and representations in children's stories (Fawcett Society, 2019).
- Parents more confident in giving advice about engineering and technology careers were more likely to say they find the idea of their child pursuing engineering appealing if they were a boy. Of the parents of girls who said it was unappealing, 15% said this was because it is a career for men. 36% of parents agreed that there are natural differences between men and women that make men better suited to a career in engineering (2021 EBM report). Seven times as many parents could see their sons working in construction (22%) when they grow up, compared to just 3% for their daughters, while almost three times as many could see their daughters in nursing or care work (22%), compared to 8% in relation to their sons (Fawcett Society, 2020).
- Teacher biases have long-term implications, particularly for female students, affecting their career prospects and earnings (Lavy & Megalokonomou, 2021). 10% of STEM secondary school teachers agree that there are natural differences between men and women that make men better suited to a career in engineering (2021 EBM report). Boys and students with high cultural capital are most likely to report receiving support and encouragement from their teachers to achieve well in science, and to continue with it (Aspires, 2020). In addition, gender stereotyping is missing from teacher training despite its importance (Let Toys Be Toys).
- Peers are a primary source of information about educational and career opportunities. They share experiences, resources, and advice, which can influence decisions about subject choices and career aspirations (EngineeringUK, 2020). They can reinforce traditional gender roles through their interactions. For example, boys might encourage each other to pursue careers in fields like engineering or technology, while girls might be steered towards careers in teaching or nursing. Young people may feel pressured to conform to the career paths that are deemed acceptable by their peer group.

Family Influence: The ASPIRES 2 evidence shows that families constitute the greatest source of influence on 10-14 year olds' aspirations. Children from families that are familiar with the world of science and technology are much more likely than their peers from families without this familiarity to want to study science post-16 and/or work in science careers. As mentioned above, parents can hold gender stereotypical views. The UPMAP evidence shows that compared to boys, girls tend to receive substantially less encouragement from their families and significant others to consider and pursue STEM careers. This differential encouragement is particularly important given UPMAP's finding that one of the most significant factors influencing post-16 participation in physics and mathematics is whether the individual had, over time, been specifically encouraged to continue with the subject by a key adult (usually in their family or at their school).

Peer Influence: There is anecdotal evidence that being part of a peer group that values and engages in STEM activities can foster a collective interest in engineering, and this can support and encourage girls.

Role Models: A lack of diverse role models can reinforce stereotypes. There are fewer visible female role models in engineering, making it harder for young women to envision themselves in these roles (RAEng,2023). For instance, if young girls do not see women in leadership roles in engineering, they might believe these careers are not for them. The decline in the proportion of women in the workforce, as described in the context section, may have an impact on the visibility of women in leadership roles.

Media Bias: As mentioned above, the media influences children from a young age, playing into and exacerbating gender stereotypes (Let Toys Be Toys). Women are often underrepresented in media portrayals of engineers and technologists (as these field are dominated by men) and so media often reinforces stereotypes that these are careers for men. Studies have shown that nearly 90% of characters in STEM roles in popular films are male. This can discourage young women from pursuing engineering careers, as they may feel that they do not belong or that they will face significant barriers (ITU, 2021). When women are portrayed in the media it is important that this is prominent and appropriate; when these portrayals are rare or unrealistic, they can make the profession seem unattainable. The way media portrays the challenges and successes of women in engineering can impact young people's perceptions. If the focus is primarily on the difficulties women face, it can discourage them from entering the field (ITU, 2021).

Social Media: Social media platforms use algorithms to curate content based on users' past behaviour, such as likes, shares, and comments. Users are more likely to see content that aligns with their existing beliefs and interests with content being differentiated by gender. In addition, people tend to engage with content that confirms their preexisting views while avoiding content that challenges them. This is facilitated by algorithms, which prioritise content that users are more likely to interact with. This personalised content can amplify users' beliefs and attitudes (Arendt, 2023) and has the potential to therefore reinforce stereotypes and may skew what role models people see.

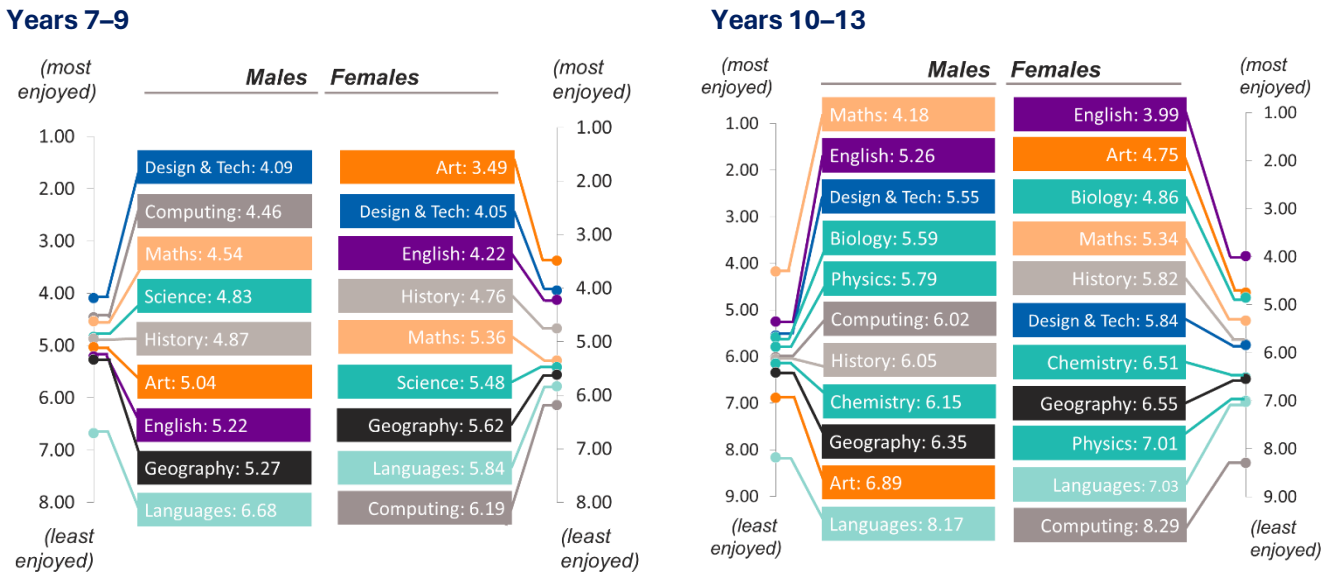
Discrimination: Peer sexism is a significant issue affecting young women in STEM education fields. Analysis of ASPIRES 3 survey data reveals that young women on an undergraduate STEM degree course, particularly in physics (50%) and engineering (30%), report higher instances of sexism compared to those in non-STEM fields. This sexism often comes from male peers and includes acts of disrespect, questioning women's academic legitimacy, and ignoring or patronising them. These issues are not limited to university settings but also occur in schools and colleges. This could increase with the rise of social media. Harmful content is gamified and presented as entertainment through the algorithmic processes of social media platforms, as a result, ideologies, such as sexism and misogyny, are normalised amongst young people and seep into their everyday interactions (UCL, 2024). We are seeing that many young women who continue with physics progressively 'downplay' their femininity in order to better fit the masculine image and culture of the subject (Aspires, 2020).

Educational Influences

Teachers' attitudes and behaviours, young people's experiences of STEM subjects, and the nature of the curriculum play a part in reinforcing or undermining science aspirations and identities (Aspires 2, 2020).

Enjoyment of Subjects: Enjoying a subject is the most likely reason that students give for being interested in a STEM career, but enjoyment of subjects varies by gender. Boys enjoy every STEM subject more than girls except for biology at Key Stage 4 in England (with D&T at Key Stage 3 being similar for both). There are gender differences at Key Stage 3 for Science and D&T, but the largest STEM subject gap is for computing, which is ranked 2nd for boys and last for girls (see figure 1). (Science Education Tracker, 2024)

Figure 1: Mean enjoyment rankings at years 7–9 (key stage 3) and years 10–13 (key stage 4) by gender (2023)



Enjoyment and encouragement to learn science will relate to a variety of factors, here we consider teaching, curriculum content, and educational achievement as key drivers (also see confidence and achievement in the next section).

Curriculum Content: While science, technology, and mathematics (STEM) are all part of the National Curriculum, engineering doesn't receive as much attention as the other subjects (EngineeringUK, 2020). At primary level, the National Curriculum does not include any engineering content. At secondary level, the availability of GCSE Engineering in schools is limited and there has been a significant decline in the number of entries for this subject, with a 63.2% drop in the past five years (EngineeringUK). However, there was a 10% increase in GCSE's in 2024. This is a positive sign, especially considering the significant decline in previous years. Most students therefore come into contact with engineering in other subjects: Design and Technology (D&T), which has large amounts of content directly relating to engineering and, through physics, biology, chemistry, computer science and geography, which all have opportunities to include engineering content, but very little is actually included in the National Curriculum.

There is a much broader array of subjects available at National 5 level in Scotland (GCSE equivalent), and the more "practical" subjects seem to be taken up at higher rates (EngineeringUK, 2024).

STEMettes has highlighted the paucity of women and non-binary role models named in the key stage 3-5 statutory curriculum for science, maths, engineering and computer science – which include a total of 20 male and 1 female/non-binary individuals.

Teaching Quality: Having a good teacher was selected by 40% of girls and 33% of boys at Key Stage 3 as encouraging them to learn science, whereas 23% of girls and 16% of boys said they had been put off by their teacher(s) – this suggests that girls are more sensitive to the quality of teaching (Science Education Tracker). This is particularly unfortunate given that a significant number of schools do not have enough specialist STEM teachers. Approximately 64% of state secondary schools in the UK report being understaffed in at least one of the key sciences (RSC, 2023). Additionally, the shortage of physics teachers is particularly acute, with recruitment targets for physics specialists being significantly below target (STEM Learning, 2023). This shortage can impact the quality of STEM education, with non-specialist teachers teaching STEM subjects, limiting students' opportunities to engage deeply with and be inspired by these subjects. Additionally, teachers who are not confident in their subjects may be anxious about teaching it and they convey this to their students. Only five percent of primary school teachers have a STEM background, and therefore have little confidence in delivering any engineering content as part of their school syllabus (IET, 2022). Primary school teachers are typically female and are unlikely to be STEM graduates, and there is some evidence that female primary school teachers who are anxious about maths can transmit this anxiety to their female but not their male pupils (Beilock, Gunderson, Ramirez, Levine, 2010).

Practical Work: Practical work was the most likely reason students give for being encouraged to learn science – selected by 54% of girls and 50% of boys at Key Stage 3. Unfortunately, there has been a significant decline in hands-on practical work in science in England, especially at GCSE level. The proportion of students in years 10–11 doing hands-on practical work at least fortnightly dropped from 44% in 2016 to 26% in 2023. This decline has been attributed to several factors, including a change to the way that practical science is assessed and the impact of COVID-19 lockdowns. The large majority of students express a desire to do more practical science (Science Education Tracker 2024).

School Options: Schools can have limited subject offerings, or limit the combinations of subjects, which can restrict students' choices and reinforce gender stereotypes, for instance if subjects typically taken by male students, such as computing, are in the same timetabling block as subjects typically taken by females. Educational gatekeeping practices, such as the stratification of science routes at Key Stage 4 and stringent grade entry requirements for science A levels, channel and constrain young people's science choices, aspirations, and progression (Aspires 2, 2020).

Career Advice: Despite developments in career information, advice and guidance there is still room for improvement to ensure that students receive comprehensive and contemporary careers advice about engineering and technology and the variety of routes in. Disappointingly, a recent study by the Careers & Enterprise Company (CEC) showed that in every year group in England, girls score lower on career readiness than boys by about 4%. EngineeringUK's 2024 survey of school staff with responsibility for careers found that 30% of respondents report that female students have a lower take-up in STEM-related careers activities compared to their peers, something not reported for general careers provision take-up. ASPIRES, found that careers education provision was patterned by social inequalities, with working-class, minority ethnic students, girls and lower-attaining students being significantly less likely to receive and benefit from high quality careers support. They also found that most young people and parents have narrow views on where science qualifications can lead, typically seeing them as pathways only to careers as scientists, science teachers, or doctors. This lack of awareness about the broader value and transferability of STEM qualifications in the labour market hinders STEM participation. The UPMAP study reinforced this, showing that perceived material gain is a key factor in students' decisions to study physics post-16. Employers tend to deliver careers activities to older rather than younger

secondary age students (CEC, 2023), despite the fact that most young people start to form their attitudes and their perceptions of STEM careers as 'not for me' between the ages of 10-14 – before key stage 4.

Essential Skills: Young people with essential skills, such as communication, teamwork, problem-solving, and resilience, tend to have a better chance of progressing to higher or further education and improved overall life outcomes. Skills like effective communication and teamwork can improve classroom participation and group work, leading to better grades (Skillsbuilder).

Mental Health: Mental health issues such as anxiety and depression can negatively affect academic performance, leading to lower grades, reduced motivation and progression (NASP, 2020) and young women are twice as likely as young men to have a probable mental health problem (NHS Digital, 2020). Studies have shown that poor mental health between ages 13 and 15 is linked to lower achievement in exams like GCSEs and later unemployment. Poor mental health is associated with higher dropout rates in both vocational and higher education (NASP, 2020). A significant number of young people feel that their educational environment exacerbates their mental health issues with 78% of young people saying that school had made their mental health worse (Mind).

Informal Education: As engineering doesn't feature highly in school curriculums, high-quality impactful STEM engagement activities are vital in helping to inform and inspire young people towards careers in this industry. For girls it is important to engage at a young age, include activities that challenge gender stereotypes around engineering and technology, take a user-led design approach, use role models of a similar age to bridge the gap and showcase a range of careers (EngineeringUK, 2023). However, girls are slightly less likely to engage in STEM related activities at school, especially in clubs and projects outside of lesson time. Specifically, 52% of girls report not participating in any such activities, compared to 47% of boys (Science Education Tracker 2024).

School Type: It has been noted that girls perform better in science and are more likely to choose physics A levels in single sex schools. However, recent analysis has found that this is mostly accounted for by the higher academic performance of girls entering single sex schools rather than the single sex environment itself.

Personal Influences

Attainment & Self-Confidence: Girls in the UK tend to perform better academically than boys at all educational stages, including higher attainment in GCSEs and A-Levels. However, girls' self-perception of their ability is lower than boys for STEM, but not arts subjects, although their attainment in STEM subjects is typically, at least on a par with boys. In fact, TISME research shows that those who are traditionally under-represented in post-16 physical sciences and mathematics (notably girls, working-class and certain minority ethnic pupils) tend to be less confident in their abilities and are less likely to identify themselves as being 'good' at science and/or mathematics, irrespective of their actual abilities and attainment. The Science Education Tracker found that there is variation in the proportion who think they are 'good' at the subjects: for KS3 science, 53% for boys and 43% girls thought they were good, and for computing, 53% for boys and 33% for girls; at KS4, 51% girls and 46% boys thought they were good in biology, 36% girls and 45% boys for physics, 36% girls and 39% boys for chemistry and 16% girls and 33% boys for computer science. The UPMAP survey of 23,000 12-15 year olds found that girls who want to study physics post-16 report lower confidence in their abilities than boys, despite no difference in their tested abilities. Issues of self-confidence are further exacerbated by the 'brainy' image of science. For instance, the ASPIRES surveys found that over 80% of Y6 and Y8 students see scientists as 'brainy' and those girls who did express science aspirations defined themselves (and were defined by their parent/s) as being 'academic' and 'bright'/'clever'. Many middle-attaining students enjoy mathematics and/or science but do not see post-16 participation as being possible for them (and often thy are

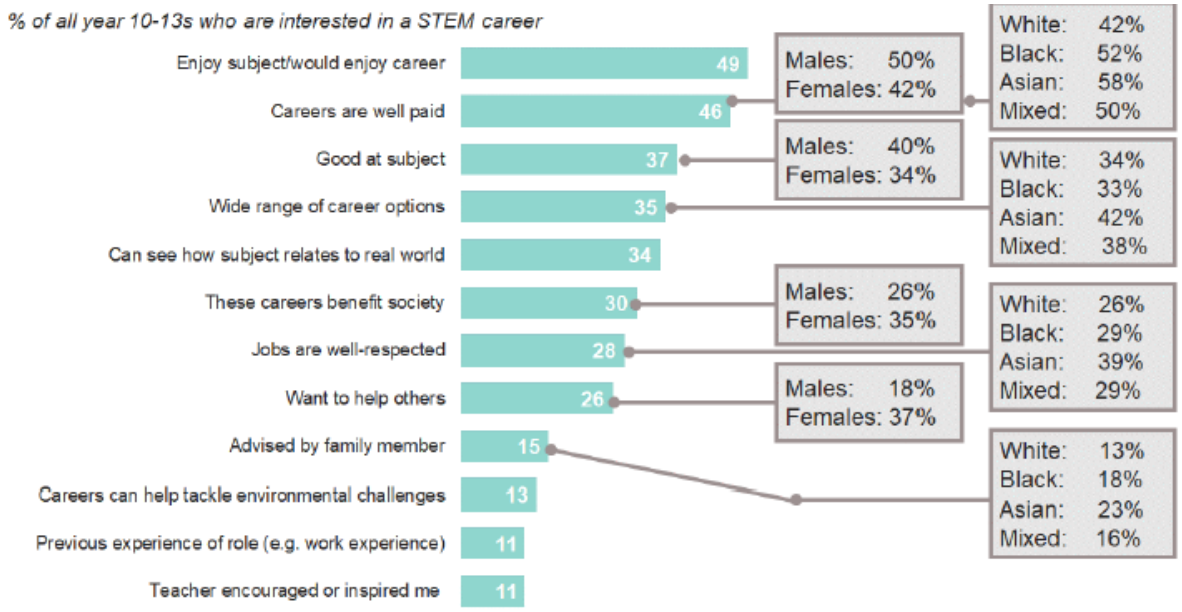
deterred from progressing into science and maths A levels without at least GCSE grades 7) - they see science careers as only for the 'brainy' few. Wider research underlines how notions of cleverness are gendered (classed and racialised), making it harder for girls, working class and some minority ethnic young people to see themselves as authentically 'clever' (e.g., Archer 2008; Archer & Francis 2007). It's likely that this effects their subject choice. It may be that girls are judging their performance in STEM not against external metrics, but against their own performance in other subjects, and, on average, they will be correct in their assessment – that is, girls typically perform best in English, humanities, and the arts, where they outperform boys, as compared with STEM subjects, in which they are comparable. Indeed, there is some evidence that girls are sensitive to the relative strengths (i.e., the extent to which they themselves are better at STEM than other subjects) and that this positioning in the class affects their later subject choices – this was not a factor for boys.

Gender differences in performance or confidence in abilities underpinning STEM may also be impactful.

> **Maths Skills:** Gender differences in enjoyment of maths, which likely links to self-perception, may underpin confidence and aspiration in other STEM subjects and there are again gender differences here. Enjoying the maths in science was selected by 8% of girls and 14% of boys at Key Stage 3 as encouraging them to learn science, whereas 23% of girls and 9% of boys said they had been put off science because they find the maths difficult (Science Education Tracker, 2023).
>
> **Spatial Skills:** Research indicates that boys often outperform girls in both large-scale and small-scale spatial abilities. This difference is observed from an early age and can be influenced by the types of toys and activities children are encouraged to engage with. Boys are more likely to play with toys that promote spatial skills, such as building blocks, construction sets, and video games. These activities help develop spatial reasoning and problem-solving skills. In contrast, girls are often encouraged to play with toys that emphasise social and nurturing roles, which may not provide the same opportunities for developing spatial skills. Studies have found that girls report more anxiety about performing spatial tasks compared to boys, even from a young age. This anxiety can be linked to societal stereotypes that suggest boys are naturally better at spatial tasks, which can discourage girls from engaging in activities that develop these skills.

Career Perception: Only 12% of girls say being an engineer fits well with who they are, compared with 38% of boys, and just 16% of girls think engineering is suitable for them as compared with 44% of boys (Science Education Tracker). Girls were less likely than boys to see engineering as creative (68% as compared with 76%) and allowing people to work in various roles (59% compared with 73%). While male and female respondents in years 10-13 were most interested in STEM careers because of enjoyment (49% selecting this reason), pay was more motivating for males than females (50% vs 42%) and also being good at the subject (40% for males vs 34% for females), while females were more incentivised by a desire to help people (37% vs 18%).

Figure 2. Reasons for interest in a STEM career among year 10–13 students who expressed an interest in this (2023), overall and by gender and ethnicity



Why are you interested in a career involving Science, Computer science, Engineering or Maths? (Carwhy)
Bases: Year 10–13s interested in a STEM career (3,067); white (2,065); Black (247); Asian (454); mixed (188); males (1,574); females (1395)

Additionally, girls might prioritise careers that they perceive as more socially impactful or aligned with caregiving roles. In addition, lack of awareness and narrow views of where science at school may lead hinders STEM participation: The majority of young people and parents who took part in the ASPIRES study reported narrow views on where they think science qualifications can lead. Most saw science qualifications as leading only to careers as a 'scientist, science teacher or doctor'. There is little general awareness among parents and children of the potential wider value and transferability of STEM qualifications in the labour market.

Self-Description: There is much social science research on identity formation which indicates that a student's identity affects his/her interests and motivations. STEM identity is particularly influenced by the fact that scientists are typically seen as male, white, and middle class so there is an identity conflict for those students whose self-identity with these groups. Many of the current STEM interventions have been based on a limited range of activities and types of careers, for example the archetypal engineer building bridges or things that fly. However, this misrepresents the range of activities undertaken by people with STEM qualifications in the STEM workforce. It also only really engages those who self-identify as doers – using verbs – and seek an output of their occupation (on average males). It doesn't engage those who seek to understand and identify with the sort of people who do those jobs – those who self-identify using adjectives – and seek job satisfaction from the impact of their work on others (on average females). It is argued that only by enabling students to reconcile their self-identity with a STEM identity will they see STEM as 'for people like me' (Macdonald, 2014).

What Might Work?

EngineeringUK has drawn together a range of evidence on interventions which impact girls' pathways into engineering including responses from a small scale call-out in June 2024. We collated and reviewed the evidence considering robustness and likely impact specifically on reducing gender differences. We've grouped these findings into interventions involving **practice, campaigns** and **policy**, and are also aware that one of the outcomes of the workshops might be identifying the need for more **research** in a specific area.

This is very much a starting point, we want to build a collective knowledge about what works, where there are promising practices and recommended areas to focus.

Evidenced Interventions

Take a Whole School Approach to Improving Gender Balance (Institute of Physics, 2017)
For over 30 years, only about 20% of A-level physics students have been girls, despite efforts to increase this. From research and pilot projects, it was deduced that work to increase girls' participation in physics should – at least in part – operate across the whole school, involving students, teachers of physics and of other subjects, senior leaders, parents and governors, and it should tackle biases and stereotyping. Gender-balance projects trialled interventions of this type and found each strand of the projects had some positive impact, **but a combined approach had a transformational effect**, with the number of girls taking AS-level physics in the participating schools drastically increasing from an average of 16 to 52 over two years. The individual interventions were: (**1) schools' analysing gender balance in A-level classes and comparing with national averages to identify trends and set higher aspirations; (2) surveys of teacher awareness of impact of equality policies; (3) unconscious bias training and development for all school staff; (4) subject-image surveys; (5) School Action Plans including gender balance initiatives integrated into the school development plan to ensure sustainability; (6) options evenings which engaged parents and students in discussions about subject choices and career paths, highlighting the importance of STEM**. The individual components demonstrated some impact when delivered in isolation. Recommendations for schools include: appointing a gender champion, analysing gender progression data, implementing inclusive teaching strategies, encouraging growth mindset and self-efficacy, training teachers on unconscious bias, raising student awareness, reviewing the options process, and considering project-led science clubs. A randomised control trial testing this whole school approach is currently in progress. Drawing on these positive findings, in addition to wider research, a consortium including the Institute of Physics, King's College London, University College London, and the University Council of Modern Languages have founded the "Gender Action" schools award to promote a whole-school approach across settings from nursery level upwards. The award launched in 2019 with funding from the Mayor of London's office, and is now a national programme led by DECSY with 300 nurseries, schools and colleges registered.

Increasing Careers Awareness

Career Readiness: A recent study by the Careers & Enterprise Company (CEC) showed that careers activities accumulate to increase the 'careers readiness' of young people and analyses show that young people with high career readiness are more likely to have career aspirations that align with labour market need and defy gender stereotypes. Accordingly, girls with the highest career readiness are two times more likely to aspire to go into engineering.

Career Related Learning: The 'Our Future Derby' project, managed by Education and Employers in partnership with Learn by Design and DMH Associates, was launched in 2019 to expand children's horizons and challenge stereotypes by introducing them to role models from various professions. The project supported 33 primary schools in Derby's most deprived wards

and later extended to schools in Derbyshire, Nottingham, and Nottinghamshire. In 2022, over 9,000 children from 52 primary schools participated in 131 career-related learning activities with volunteers from diverse backgrounds. The evaluation involved over 1,600 children, 35 teachers, 104 volunteers, and 239 parents, showing a positive impact on children's aspirations, skills, and understanding of the link between school learning and the world of work. The project also addressed gender stereotyping and positively affected teachers and volunteers. The most impactful activities identified by teachers was The Robotics Challenge and Destination Rail.

STEM Careers Awareness in the Curriculum

A potentially useful approach that is used in other countries (and which a US randomised control trial has shown to raise student attainment and motivation, particularly among under-represented groups) is to embed information about how STEM is used in the world, and about the people who use it, throughout the curriculum. This approach has the advantage of reaching a wide range of students – whereas current extra-curricula and optional approaches tend to only reach small numbers, and sometimes an uneven social or geographical spread, of students. However, teachers will need support and training if this approach is to be adopted – and the national curriculum and assessment would need to be adapted to enable and encourage uptake of this approach (Rose, Woolley, Orthnew, Akos, Jones-Sanpei, 2012).

Growth Mindset

A growth as opposed to fixed mindset has been shown to be a predictor of attainment in STEM and several studies have shown that a growth mindset can be influenced. For instance, Dweck (2008) reported an effective intervention to improve maths growth mindset, compared to a control group, with girls showing greater gains than the boys. A study in the US implemented a growth mindset intervention with 143 children on a visit to a museum to promote children's incremental ability beliefs and investigate the relation between the intervention and children's gender stereotypes. Participants exposed to a growth mindset intervention, compared to the participants in the control condition, reported significantly less gender stereotyping around STEM as per the stereotype awareness measure (Law, McGuire, Winterbottom and Rutland, 2021).

Promising Interventions

Challenge Gender Stereotypes

(Note that this approach underpins the whole school approach to improving gender balance described first in the intervention section.) Research indicates that teaching students and teachers to deconstruct (discuss, take apart, understand and challenge) stereotyping is more effective and long-lasting than simply providing positive images of scientists or STEM (Davies, 1996). The most effective teachers are those with gender-neutral attitudes, suggesting that improving teacher quality can reduce gender discrimination in schools (Victor Lavy & Rigissa Megalokonomou, 2024). Lifting Limits has carried out small-scale programmes in primary schools to challenge gender equality and these show promising results. In 2013, The National Union of Teachers worked for two years with five primary schools to consider how 'traditional' gender stereotypes could be challenged in nursery and primary classrooms. The 'Breaking the Mould' project provided teachers with support and resources so that they could challenge stereotypes in the classroom, with those who took part in the project suggesting that it made them reflect on how they had interacted with children and caused them to alter their behaviour.

Mixed Evidence

Role Models Impact on Career Aspiration/Attainment

Girls being exposed to examples of female STEM roles models has long been believed to impact a range of factors which influence their pathways into STEM and therefore there is quite a breadth of studies

which have tested this as an intervention. However, the evidence on the effectiveness of these interventions is mixed. A review covering fifty-seven empirical studies found significant heterogeneity in role models, interventions, variables, and effects. Common role models include female STEM professionals or mixed-gender groups, and interventions often involve participants reading about the role model. This diversity makes it challenging to assess the overall effectiveness of role model exposure. Future research could investigate how different characteristics of role models impact the success of these interventions (De Gioannis, E., Pasin, G. L., & Squazzoni, F. (2023)).

Additionally, EngineeringUK's rapid review (2023) which had a more specific focus on interventions that aim to increase girls' aspirations for engineering and technology careers, found that of the 14 interventions involving role models and mentors, eight found positive short-term effects on girls' engineering and technology career aspirations, two found adverse negative effects and four found mixed results or no change. However, the key learning related to role models from the analysis was to involve role models in club activities - their involvement can expose students to educational or professional STEM pathways.

Additionally, a study (2020) evaluated the impact of a maths role-model intervention on 304 Spanish girls, 12-16 years old, in which female volunteers working in STEM visited schools to talk to girls about their careers. The results showed that female role-model sessions had a significantly positive effect on girls' mathematics enjoyment, expectations of success and girls' aspirations in STEM. They also had a negative impact on gender stereotypes and significantly increased the girls' expectations of success in STEM choices. Girls in STEM: Is It a Female Role-Model Thing? - PMC (nih.gov)

Role Models' Impact on STEM Performance: Girls' exposure to female STEM role models might improve their subsequent performance in STEM subjects. At least one US study supports this idea a US study which included 81 students, 13-17 years-old (29 male, 52 female), who read one of three chemistry lessons, each containing the same text, with photograph content varied according to stereotype condition: either all-female, all-male, or a mix of female and male scientists. Students then completed a comprehension test and anxiety measure. The results showed that female students had higher levels of comprehension after viewing the counter-stereotypical images which included female scientists compared to viewing stereotypical images of male scientists. (The effects of gender stereotypic and counter-stereotypic textbook images on science performance - PubMed (nih.gov)). Educators and Employers found career gender stereotyping exists, and it can be tackled from primary school onwards, through expose to role models.

Policy Context

Lots of the issues identified above relate to or could be mitigated by government policies and actions and most policy changes include an equality impact assessment. Several actions taken by the Westminster government and devolved administrations have explicitly attempted to increase the number of girls in STEM or engineering and technology (e.g., the Your Life campaign, some of the previous government's Taskforces identified actions or commitments about improving workforce diversity, some government contracts may include EDI requirements, DfE funded research on bringing more Girls into computing – the GBIC trials, DfE funding for the Inclusion in Schools programme, Education Scotland's work on Improving gender balance and inequalities), but we don't believe that they have resulted in well-evidenced impacts nor taken to scale.

Below we identify some areas that are 'live' in terms of policy development under the new government and might provide some opportunities for action or it may be that there are other areas for exploration (e.g., targets for apprenticeships, changes to teacher training, reform of accountability systems, support for extra-curricular activities etc.).

Curriculum & Assessment Review
The government has launched a review of the national curriculum and assessment in England, aiming to address barriers to achievement from Key Stage 1 to Key Stage 5. The call for evidence ends on 22 November 2024 and will identify areas for improvement. There is a drive throughout the document to reduce inequality based on socioeconomic disadvantage, but there may be an opportunity to make the case to address the inequality in take-up of engineering and technology by gender, especially given that jobs in these areas are significantly more highly paid than others.

Skills England
Skills England is being established to address the skills needs of the next decade across all regions. Expected to be fully operational by April 2025, it will function as an arms-length body under the Department for Education. It will absorb the roles of the Institute for Apprenticeships and Technical Education and the Unit for Future Skills, and aims to develop a comprehensive picture of national skills needs, drawing in insights from various skills taskforces, identifying priority training areas, and ensuring that both national and regional skills systems meet these needs. Skills England will also be providing sharing insight with the **Migration and Advisory Committee** which has been asked to provide evidence on skills shortages over the next 9 months that will underpin skills strategies for engineering and for technology and telecommunications.

Growth & Skills Levy
The government has announced significant reforms to apprenticeships in England, introducing a new growth and skills levy to replace the existing apprenticeship levy. The new growth and skills levy will include foundation apprenticeships and allow for shorter, more flexible training programs. The reforms aim to provide young people with career opportunities in critical sectors, enabling them to earn while they learn, and to address the nation's priority skills needs as identified by Skills England. Employers will be asked to invest more in younger workers and fund higher-level apprenticeships outside the levy.

Careers and Work Experience
Labour pledged in the manifesto to train over a thousand new careers advisors and ensure all careers advisors have up-to-date knowledge of post-16 pathways. This initiative aims to provide every young person with access to professional advice and guidance at their school or college. The manifesto made a pledge to guarantee two weeks' worth of work experience for every young person and improve careers advice in schools and colleges. The total cost for both policies is estimated at £85 million.

STEM teachers
The government has announced funding to recruit 6,500 more teachers, including in shortage areas. Given the acute STEM teacher shortages across England, it is expected that part of this recruitment will focus on addressing this issue. Currently, there are no formal opportunities to provide input.