INFLUENCING EDUCATION CHOICES AND PATHWAYS

Introduction

The UK Commission for Employment and Skills found that 43% of vacancies in roles involving science, technology, engineering and mathematics (the so-called STEM subjects) are hard to fill—almost double the UK average of 24%[1]. There is also a major gender imbalance with male dominance across STEM school subjects, university courses and jobs[2]. This matters because every young person should have the right to study the subjects that interest them without pressure to conform to arbitrary cultural norms about gender roles. It also matters because the resulting lack of diverse opinions and perspectives in the STEM sector is likely having a negative impact on creativity and innovation in engineering, with knock-on effects to productivity and financial returns.[3] Every child with an interest in STEM subjects should be given equal opportunities, information, and support to pursue a career in STEM.

Reports addressing the STEM skills crisis often talk about the need to service the skills pipeline shortfall using interventions aimed at building up young people's skills and interest in STEM. However, this frames the issue in a way that suggests an intrinsic lack of motivation or capabilities among young people. In reality, the dynamics underpinning school subject and career pathway decisions are complex and interconnected. They are influenced by structural issues, such as reinforcing cycles of social and economic inequality, entrenched stereotypes and media portrayals of the engineering profession, and a lack of a curriculum presence for engineering. This contributes towards low levels of awareness and understanding of STEM opportunities at the points that young people make subject and career choices.[4]

EngineeringUK is seeking to better understand: the factors influencing young people's educational choices, with a view to identifying the most effective engineering outreach opportunities to influence educational pathways; what considerations we may need to make for different demographic groups; and developing more specific and effective measures. As part of this endeavour, NPC has been commissioned to conduct a review of the literature covering: conceptual frameworks and influencing factors involved in young people's decision-making in educational subject choices and future careers; the 'what works' evidence; gaps in the knowledge base; and current evaluation approaches for STEM outreach interventions. In addition to the literature review, this report also includes various insights from a series of expert interviews with key stakeholders involved with engineering and STEM outreach, and researchers of educational choices. The key findings from this report will be used to inform the development of a shared impact framework, an open source toolkit to guide those working in STEM outreach in thinking about how activities can collectively influence young people's decisions to study STEM and pursue engineering careers.

We are publishing this report alongside a visualisation of the key findings. The visualisation will enable readers to quickly grasp key concepts, themes, and insights, and the report will help readers to explore the topics in more detail, with links to the original sources for those looking to dig deeper into the evidence.

Strengths and Limitations of the Review

The principal strength of the review is that it covers a wide range of research, which is broadly reflective of the complexities involved with young people's subject and career path choices, attitudes and behaviours. In addition to summarising the available evidence for each research question, the final section seeks to integrate the findings into a series of initial recommendations for the planned development of a theory of change. The authors were also fortunate to be able to speak with a good spread of experts from across the sector.

Equally, the review has limitations that should be kept in mind when interpreting the findings. As a rapid review, it is by no means an exhaustive summary of the literature. Rather, it has sought to prioritise the most relevant studies (primarily from the UK) and to identify key messages and themes. In that respect, it offers an introduction to the topics discussed and should be supplemented by further research.

Executive Summary

Understanding the complexity of young people's school subject and career choices is no easy task. The range of influencing factors is broad, interconnecting and hard to measure. The conceptual frameworks that have been proposed to help make sense of this issue tend to fall into one of four groups: linear stages, segmented groups, nested systems or building blocks. As discussed in Section A, there are advantages and disadvantages of each framework type. The accompanying visualisation attempts to include elements from all four dimensions: time (shown by the linear stages), individual differences (the five segments), multiple layers of influence (the semi-circles of influencing factors), and skill or knowledge acquisition (located in the central "education choices and pathways" box).

The influencing factors in Section B have been arranged in order starting with individual factors like gender and ethnicity, and ending with macro-level issues such as cultural norms and the national curriculum. Factors in between include regional career prospects, subject choice availability, perceived subject difficulty, previous exam results, teacher quality, peer group influence and university or apprenticeship entry requirements[5]. Given the wide range of influencing factors and the length of time involved, there is unlikely to be a single intervention or organisation capable of sufficiently increasing the overall proportion of people choosing STEM subjects or redressing the engineering gender imbalance. For complex adaptive problems like STEM inequality, what is required is a collaborative ecosystem of outreach intervention organisations with a shared understanding of the relevant systemic issues and a commitment to generating more reliable evidence about 'what works'. This has been recognised across the sector, most recently by the Royal Academy of Engineering[6], the National Audit Office[7], and EngineeringUK[8].

Given the scientific nature of the issue, it is surprising how little robust evidence has been published about the effectiveness of STEM outreach activities. As discussed in Section C, high-quality impact evaluations do exist but they are few and far between. A key theme from the available evidence is that prolonged STEM outreach engagement tends to be more effective than one-off interactions[9]. Given the broad range of STEM outreach activities[10], the most pressing gaps in the evidence base concern identifying which types of intervention are the most impactful (and cost-effective). There is also a lack of coordination across the many different activities, and a lack of clear guidance informing implementation considerations and the facilitators and barriers to delivering successful STEM outreach.[11]

Section D concludes that most current evaluations of outreach intervention impact are small-scale, short-term and lack a counterfactual (control group). With such a broad range of organisations and activities involved with outreach interventions, creating a single evaluation framework that works for every stakeholder and scenario will be no easy task. A useful first step could be to agree on a common sector language (for example, what do we mean by "engineering", "reliable evidence of impact", and so on), and set some evaluation principles that can be applied and adapted as required across the sector.

Section A: Conceptual Frameworks and Influencing Factors

To help make sense of the complex dynamics influencing childhood development, aspirations and career path choices, various conceptual frameworks have been developed. Effective conceptual frameworks help to communicate an overall picture of a research topic's findings, organise ideas and make the underlying insights easier to remember and apply. The frameworks and theories published to date can be grouped into one of four types: linear stages, segmented groups, nested systems, and building blocks.

Linear Frameworks

Step-by-step frameworks with specific childhood development stages

A frequently cited linear approach is Erikson's nine-stage Theory of Psychosocial Development.[12] This framework lays out a series of development conflicts. For example, "Identity Versus Identity Confusion"—the fifth stage of the model—is when Erikson believes that adolescents (aged 12–18) start to explore their independence and develop a sense of self. The confusion part of the conflict comes from feeling insecure about themselves and how they fit into society. The way to resolve this crisis, Erikson argues, is to explore different options and then commit to an identity, career path, social group, and personal style.

Segmented Frameworks

Typologies for grouping young people based on characteristics, behaviours and attitudes

Researchers reviewing the STEM-related evidence often categorise young people into two groups: those who see a career in a STEM area as being either 'for me' or 'not for me'.[13] A more nuanced grouping can be found in the "Five Tribes" segmentation from the Institution of Mechanical Engineers.[14] This cluster analysis of a representative sample of young people in the UK aged 11–19 grouped people according to their values and attitudes towards school, family and work, and their attitudes towards engineering as a subject and as a potential career. The five segments ranged from "STEM Devotees", who tended to enjoy STEM subjects and had strong STEM capital (87% cited family STEM links), through to "Less Engaged", characterised as being relatively less connected to school, having lower levels of confidence or interest in wider social values, and being the least adventurous group. The implication from this segmentation is that STEM outreach interventions could use a greater understanding of their target audiences and the factors that influence each segment to adapt their strategies.

Nested System Frameworks

Circles of influence showing how the individual is connected to a complex network of systems

More complex theories of childhood development include Bronfenbrenner's socio-ecological model, which identifies five tiered systems.[15] At the core of Bronfenbrenner's framework is the child's biological and psychological makeup. The system layers which are close to the individual in the centre, such as family and peers, contain the most direct influences, with progressively distant factors on the outer layers (school, neighbours, church, mass media, industry, cultural values, and so on). By examining the various ecological systems, Bronfenbrenner's socio-ecological model is able to demonstrate the diversity of interconnected influences on children's development—useful context for those wishing to understand how children might react to STEM outreach in different settings.

Building Block Frameworks

Accumulating relevant capabilities, experiences and knowledge

In *The Forms of Capital* (1986), Pierre Bourdieu, a sociologist, first made the distinction between these three types of capital:

- economic capital: assets such as money and property
- social capital: social relations and networks that can 'open doors'
- cultural capital: includes things like language skills, qualifications, knowledge of cultural references, holidays abroad, and visits to galleries

Bourdieu argued that all three are important for influencing young people's career pathways and contribute to the reproduction of inequalities in society over successive generations.

More recently, in the UK, Louise Archer and colleagues (2015) developed the related concept of "science capital"—the accumulation of scientific knowledge, qualifications, interest in science, knowing a friend or family member with a science-related job, and so on. The ASPIRES longitudinal research into the aspirations of 10-14-year-olds found that science capital was a key factor affecting the likelihood of a student aspiring to a science-related career. The tracking data revealed that students with low science capital who do not express STEM aspirations at age 10 are unlikely to develop STEM aspirations by age 14.[16] Experts have shared that there has been mixed uptake of the science capital concept across the education sector, and that there exist many differing interpretations of what science capital means in practice. Therefore, to avoid confusion or a dilution of the concept, it could be widely beneficial to develop consensus among the engineering and education communities around what is understood by science capital (or STEM capital) and how it works in practice.

Another theory with a building block-type approach that is of interest to this inquiry is the COM-B system—a framework for understanding behaviour.[17] According to the COM-B model, behaviour and decisions are made on the basis of interactions between our capabilities, opportunities and motivations. Successful interventions need to influence one or more of these components in order to create behaviour change. This simple framework has been successfully used to change behaviour in other fields and has been developed into a "Behaviour Change Wheel", a structure that shows how different types of policy and interventions can influence people's choices.

A concern related to building block approaches highlighted during the expert interviews is the risk that a lack of skills or motivation could be interpreted as being the fault of the individual rather than a consequence of systemic problems and structural inequalities.

Multi-dimensional frameworks

A good case could be made for using any of the four types of framework detailed above. Linear frameworks steer users towards targeting interventions at the most impactful time points, such as just before GCSE subject choices are made. Segmented frameworks often highlight the demographic differences in engagement with STEM and emphasise the benefits of tailoring interventions to each target audience. Nested system frameworks help to communicate the complex dynamics involved and show how different factors are interconnected. Building block frameworks help to put the spotlight on societal inequalities. The difficulty in picking just one of those four frameworks is that there is a risk of focusing too much on one aspect (working out the optimal age range for an intervention, for example) at the expense of understanding the other parts of the puzzle (knowing your target audience, understanding the wider context and systemic issues, and so on). Separating factors can be problematic, and experts urge organisations to not consider structural factors and attitudes as binary influences, but as interconnected influences. Thus, attempting to alter or change one influence is potentially futile.Efforts should be focused on delivering multi-faceted interventions that seek to change multiple influencing factors – or to coordinate activities such that collectively the effect is the same.

A few multi-dimensional frameworks incorporating two or more of the four groups have been suggested in recent years. The Skills Builder Partnership framework, developed by a partnership of schools, employers and skills-building organisations, breaks down eight skill areas (problem-solving, leadership, and so on) into various steps targeted at specific age ranges.[18] A good example of a higher-level multi-dimensional framework is the OECD Learning Compass 2030, which visualises the various institutions, competencies and values involved with young people's educational journeys.[19]

Another idea that has been proposed is to use a burning candle analogy[20] to show how science capital is just one part of the education pathway equation. In the candle framework, the flame represents a young person's engagement with STEM; the candle is the student's attitudes and science capital; the match to spark the flame could be an inspirational teacher or science experience; and the environment around the candle (i.e, oxygen levels and wind conditions) represents the wider system dynamics. These include the extent of the young person's opportunities, whether or not a student's way of thinking is valued, institutional diversity, and university engineering course entry requirements. Therefore, any attempts to attract young people into STEM require a range of wider conditions to be in place for the message to reach young people effectively.

Given the complexity of the issue, we believe that a good strategy is to bring elements of each of the four types together into a single conceptual framework. The first iteration of this united framework can be found in the accompanying visualisation. The idea is that the user will be able to use the framework to find the research that is most relevant to the age groups, target audiences, system levels, and decision-making factors that are of interest to them.

Influencing Factors

Matching the visualisation, the influencing factors here are ordered broadly along the lines of the socio-ecological model. We start with the individual factors such as gender and ethnicity and then work outwards through factors that are progressively larger in scale and less directly connected to the child.

The factors listed below are by no means exhaustive - they are simply the factors which seemed to appear most frequently in the reviewed literature and for which there is evidence that that they influence a young person's capability, motivation, and opportunity to study STEM and pursue an engineering career (or educational outcomes more generally). More thorough research would be required to get a full list of all of the influencing factors involved and may also require further exploration of the factors discussed here.

Individual

Gender

The overall STEM qualification participation gender split is fairly equal. This is principally driven by high numbers of girls and women opting for biological science courses, leading to careers in areas like medicine. However, the proportion of girls and women studying engineering, computing and physical sciences is well below 50% at ALevel and university level[13] and there is acute underrepresentation of women among first degree engineering and technology university entrants (17%) and engineering apprenticeship starts (9% in England).[21]

There are myriad and complex reasons for why this may be the case. A study examining how to increase girls' interest in computer science and engineering by diversifying stereotypes sought to summarise these as follows:

> In what ways are girls' educational choices constrained? First, girls may be steered away from computer science and engineering by parents, teachers, and others who think that these careers are better suited for boys (Eccles et al., 1990; Sadker and Sadker, 1994). Second, the mere fact of having underrepresentation can perpetuate future underrepresentation (Murphy et al., 2007). If girls do not see computer scientists and engineers as people with whom they feel similar, they may be more reluctant to enter these fields (Dasgupta, 2011; Meltzoff, 2013). Third, girls systematically underestimate how well they will do in these fields, and this predicts their lower interest in entering them (Correll, 2001; Ehrlinger and Dunning, 2003). Fourth, girls may anticipate encountering greater work-family conflicts in these fields (Ceci et al., 2009). Fifth, there is discrimination in these fields that prevents qualified women from receiving the same opportunities as their male counterparts (Moss-Racusin et al., 2012). Sixth, women who enter traditionally masculine domains can be socially and professionally penalized for exhibiting competence and leadership qualities (Rudman, 1998). These are all barriers that contribute to why some women choose not to enter and persist in fields like computer science and engineering.[22]

A major theory as to why this is the case is that many young people, especially girls, view subjects like physics as being very difficult, and so only for the brainy few and 'not for them'. One explanation for the gender imbalance in subjects like physics is the "variability hypothesis": the perception that while girls might perform better overall, attainment by boys is grouped towards the tails of the distribution curve—among the highest and lowest performers—with fewer boys achieving mid-level grades. As noted in an article by Rose O'Dea, an academic from the University of New South Wales, 'greater male variability was first proposed as an explanation for men's superiority in the 1800s, and the idea never disappeared.'[23]

O'Dea's analysis of the grades of 1.6 million young people from around the English-speaking world did find that boys' grades had slightly greater variability (7.6%). So, while it may be true that we would expect to see more men among extremely high-achievers, this does not explain the gender difference in career paths such as engineering. Sadly, the false narrative that exceptional talent is required for subjects like physics may be helping to perpetuate gender inequalities. There are more than enough talented girls and women who could close the gender gaps in subjects like physics and career fields like engineering. However, girls have other options outside of STEM (girls also get higher grades in subjects like English), which do not have the same level of male stereotype associations.

A paper by academic Alice Sullivan on how rational choice theory (i.e. that people maximise the fulfilment of their desires based on their beliefs about the situation) applies to education choices has revealed some noteworthy insights relating to gender.[24] Boys significantly overestimate themselves compared to girls in their predictions for their GCSE results and in evaluating their general academic abilities compared to others at their school. So, it is possible that finding ways to increase confidence in ability amongst girls could help to increase the proportion of girls who choose subjects like physics.

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,[25] to the words their parents use to describe the world to them,[26] the representations of science they see in popular media,[27] to how their ability is assessed by teachers,[28] 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. Girls surveyed as part of the Engineering Brand Monitor (EBM) were not only consistently less likely than boys to report knowing what an engineer did, but also to believe they could become an engineer if they wanted to or that it would 'fit well with who they are'.

There is also evidence that girls are less likely than boys to seek careers advice and therefore disadvantaged in a system often delivered via self-referral,[29] which may have an effect on the opportunities they are made aware of and encouraged to pursue.

Socioeconomic background

Patterns in educational attainment and participation by socio-economic background are extensively documented, with evidence highlighting the pervasiveness of social background in perpetuating the underachievement and underrepresentation of those from relatively disadvantaged positions. Disparities in attainment and take-up have been observed across all subjects areas and at all levels of academic study, and the patterns and persistence of inequality are reflected in STEM fields also.[30, 31]

This inequality can be observed across all stages of education. 44% of pupils eligible for free school meals (FSM) achieve an A*-C grade GCSE in maths compared with 71% of non-FSM pupils, and for physics the figures are 8% and 24% respectively. In A level maths, 54% of those eligible for FSM in school achieve an A*-B grade, compared with 66% of those who were not eligible. At the higher education level, just one in ten engineering and technology first degree graduates come from the most disadvantaged POLAR4 quintile.[32]

Mainstream educational theories offer conceptualisations of and hypotheses for these disparities. Pierre Bourdieu's theory of cultural reproduction suggests that children from higher socioeconomic backgrounds enjoy advantages passed down by their parents in the form of 'cultural capital'[33]. The theory suggests that individual actions and decisions are influenced by the extent of relevant cultural knowledge in the family, where familiarity within a given 'social sphere' (e.g. higher education) is essential for success within it; those from advantaged family backgrounds, whose parents are likely to have succeeded within the education system, benefit from a head start in the race to achieving formal credentials.

There is a large body of literature which has sought to operationalise the concept of cultural capital, and it has been revised (and modernised) over time to facilitate its continued applicability, reflecting changes in the economy, new forms of cultural participation, contemporary styles of parenting and focuses on particular qualification types or subject areas.

Related concepts – in particular, the concepts of 'habitus' and 'field', which refer to individuals' dispositions, their understanding of the world (or a given social environment) and one's place within it – have proven useful for understanding how issues of belonging, entitlement, and institutional settings as being 'not for people like me' can impact on decisions to pursue further and higher education.[34,35] Adaptations of the theory of cultural capital and the concept of habitus have proven useful for furthering our understanding of the unequal representation of certain groups in STEM, including those from lower socioeconomic backgrounds.[36, 37]

Alternative theoretical approaches assume a greater degree of conscious and deliberate decision-making on the part of young people and their families. Rational choice theory posits that, when faced with an educational branching point, individuals weigh up the expected costs (including opportunity costs) and long-term benefits (salary and other) of the various options they face, along with their perceived likelihood of success.[38] The theory was developed for the purpose of understanding social inequalities in educational choice (i.e. the greater tendency of those from lower socioeconomic backgrounds to choose to pursue vocational, rather than academic, courses, or to drop out of education altogether).

The rational choice theoretical framework, however, falls short in a number of respects specific to the STEM context. The theory does not acknowledge the effects of the unequal distribution of information across groups of young people and their influencers. In the case of engineering careers, students may be ill-informed about the various options available to them – the nature of the sector, the range of possibilities in the field, average salaries, and so on – as well as the educational qualifications required for entering these roles. In a survey of businesses surveyed in the CBI/Pearson Education and Skills Survey, a lack of awareness among young people of the educational routes to enter particular careers (50%) and careers advice poorly aligned to the sector (49%) were identified as causes of the skills gap.[39] There is also evidence that young people tend to underestimate the level of renumeration enjoyed by engineers – 56% of respondents aged 16 to 19 in EngineeringUK's Engineering Brand Monitor survey in 2019 underestimated graduate engineers' starting salaries.[40] Further, information barriers have been cited as an issue which perpetuates socioeconomic inequalities, with some studies suggesting that more advantaged families tend to have access to better quality information regarding the graduate labour market.[41] The theory tends to overlook the implications of decisions which are made on the basis of flawed information.

Rational choice theory has also been critiqued for its shortcomings in relation to acknowledging the effects ofintersectionality in decision making. For example, while black and minority ethnicity (BME) young people are more likely to face difficult financial circumstances and have on-average lower performance at GCSE, they take up opportunities to pursue further educational opportunities at a disproportionately high rate. It could be that ethnic minority pupils' heightened drive for formal qualifications is in part an attempt to protect themselves against the discrimination they anticipate that they will face in the labour market (again, affecting their cost-benefit assessment, in line with the theory).[42]

Ethnicity

BME students are more likely to study STEM at school and higher education (HE) level than their white peers, though this is not necessarily the case for all BME ethnic groups. While Indian, Pakistani and 'other ethnicity' students are more likely to study STEM A levels than students from other ethnicities, Black African and Caribbean students have particularly low levels of uptake.[43]

One possible reason BME students may be more likely to study STEM subjects in school and HE could be related to differences in parental and student attitudes and behaviours. A number of studies indicate that young people from minority ethnic backgrounds – and their parents – generally have higher educational and occupational aspirations than their White British peers, and have linked these to both subject choice and educational achievement.[44, 45]

This resonates with wider research into the overrepresentation of BME young people in HE, which prima facie presents a challenge to cultural capital theory, given that they are both more likely to come from lower socioeconomic profiles, have lower school-level attainment, and suffer from additional disadvantages such as racism and cultural marginality.[46] In fact, upon controlling for social class, academic marks and school/teaching quality, the odds of attending university *increase* for all BME ethnic groups compared with their white peers, reflecting an apparent ethnic penalty for minority pupils in respect of their social class, the quality of education they receive and their school performance.[47]

However, there have been attempts to reconcile this apparent contradiction by extending the concept of 'cultural capital', with suggestions that strong familial adult-child relationships and norms enforcement among BME families can help to provide 'ethnic capital' for academic success, often in the face of adversity.[48, 49, 50] Indeed, proponents of ethnic capital theory suggest that the attitudes of some BME groups are often driven by an 'ethnic capital' to overcome disadvantage. This ethnic capital may take on different forms: it may be aspirational, for example, or resistant (e.g. a perception that there is racial discrimination within the labour market).

It is worth noting, however, that although BME people are overrepresented in STEM education, they remain underrepresented in the engineering workforce: just 9% of those working in the engineering sector are BME, compared with 12% of the UK workforce.[51]

Contributing factors for this attrition may include BME qualifiers tending to have less social/cultural capital than their white peers;[52] the degree attainment gap (i.e. BME qualifiers less likely to obtain a first/2:1 than white qualifiers);[53] graduate recruitment often targeting universities with lower proportions of BME students;[54] or real or perceived bias in recruitment practices.[55] Qualitative research from the University of Hertfordshire, for example, has found evidence of exclusionary organisation cultures at some engineering employers expressed with regards to things like recruitment preferences (some implicit, some explicit) for English-sounding names, and expectations about what an engineer looks like.[56] Similarly, a study by the Royal Academy of Engineering found that even after controlling for degree class, prior attainment and mission group of university attended, ethnicity remained a significant factor in determining employment outcomes, particularly for engineering roles.[57]

Network

Parents/family and the home environment

As has already been illuminated above, a young person's parents and family can strongly influence their educational choices and trajectory. As Archer et al. so aptly summarise, "aspirations are not simply individual cognitions residing within children's heads, unaffected by their social contexts. Rather, children's aspirations and views of science careers are formed within families, and these families play an important, albeit complex, role in shaping the boundaries and nature of what children can conceive of as possible and desirable and the likelihood of their being able to achieve these aspirations."[58] Parents and family are a key way in which young people are able to cultivate science capital, determining the degree to which they are encouraged to adopt science-related attitudes, values and dispositions, have opportunities to consume science media or participate in out-of-school science learning contexts, talk about science in everyday life, know those working in science-related professions, etc.

More generally, there is extensive evidence that parental attitudes, expectations or aspirations, involvement at school and support at home, and the family environment consistently have a positive impact on children's educational aspirations and outcomes.[59] Indeed, it has been argued that parents have more influence over early career pathways than peers or teachers.[60] Part of that influence no doubt comes from the socioeconomic status of the parents— including factors such as parents' occupation and educational attainment. For example, Desforges et, al., Gorard et. al., and Gutman and Akerman, among others, provide compelling evidence of class differences between parents in not only how much value they place on their children's education, but also how they view their role, and their ultimate level of involvement in educational activities.[61, 62, 63] Other research shows that poorer families often have high aspirations, but do not know or have the means tofulfil these ambitions – for example, by helping the child with their homework, intellectually engaging with them, or participating in school activities.[64]

However, there is also evidence that parental attitudes can make a positive difference, despite family background. Parental aspirations for children aged nine were found to be very influential in children's key stage 2 scores, even after taking account of the effects of socioeconomic status and previous attainment.[65] A related finding, which has implications for parental style (and teacher) guidance, is that young people who put their own success down to hard work, rather than chance or fate, tend to have higher aspirations than their peers.[Error! Bookmark not defined.]

Peer Group

Compared to the impact of family background and parental interventions, the influence of peer groups is less well understood in respect of pursual of STEM specifically. However, there is a significant body of literature that suggests that social interactions between peers can affect young people's educational attainment and subject choices more generally.

For example, the Centre for Vocational Education Research found the composition of secondary school peers to be an important determinant in a student deciding in favour of academic rather than vocational education.[66] Similarly, the Institute for Fiscal Studies found that those who expect their friends to continue in post-compulsory schooling are more likely to do so themselves, even after controlling for their own preferences and attitudes.[67] However, there is evidence that pupils are more likely to rely on peers when information provided by schools is poor or where they lack experience.[68]

Public information about attainment has also been found to influence performance. In an experiment conducted across 100 schools in the US, the introduction of a performance leader board resulted in a 24% decline in overall performance. The decrease appears to be caused by a desire to avoid the leader board; top performing students prior to the change had a 40% decline in performance, while poor performing students improved slightly. This insight, the authors argue, is part of a larger point about how young people are highly responsive to the prevailing norm, and that wanting to fit in can have considerable effects on how they make decisions.

School

Teaching quality and the school environment have also been found to be significant influences on subject choice and career pathways. It is evident that STEM provision varies by school, with some offering only certain subjects[69] or requiring that a set of core subjects are studied, thereby guiding their pupils towards certain paths.[70] For instance, in highly deprived local authorities such as North East Lincolnshire, half of secondary schools do not offer triple science. There is also evidence that schools in less affluent areas have fewer STEM specialist teachers than those in more advantaged areas. According to research by the Education Policy Institute, outside of London just 17% of physics teaching hours in the most deprived schools were delivered by subject specialists, compared with 52% in the least deprived schools – a gap of 35 percentage points.[71]

Access and quality of careers guidance and advice can also vary significantly by school, with the *Not for people like me* report published in 2014 reporting that many young people have poor awareness of how subject choices links to career options, higher education entry requirements, or how to access this information.[13] This point was discussed in the expert interviews where it was noted that teachers are a key information source for young people and a gatekeeper for choosing outreach activities in schools. The opportunities available to young people, it was thought, are largely due to who the teachers are speaking to, leading to disparities between different schools and throughout local areas. It was described by one expert as a "postcode lottery". A 2014 UK systematic review of the factors influencing subject choices at ages 14 to 19 also found some differences by school type and size.[72] Pupils were more likely to take physics at smaller schools, students from single-sex schools were more likely to pick more science GCSE options than mixed schools, and girls from girls-only schools were more likely than girls in mixed schools of picking design and technology. The proportion of teaching time allocated to STEM subjects was also found to be important: schools devoting a higher proportion of time to mathematics in Year 10 tended to have significantly higher take-up for A-Level mathematics.

More generally, other studies have elaborated on the importance of teacher expectations and perceptions in influencing pupils' educational outcomes. Both Merton and Goffman, for example, found evidence to support the theory of labelling – that is, that teachers disproportionately perceive pupils with certain socioeconomic backgrounds to be low achieving. This in turn negatively affects the child's sense of identity or causes them to consciously reject educational success, stimulating a self-fulfilling prophecy.[73] Further, the subjectivity of teacher expectations is often institutionalised through school processes. Strand's examination of the longituntinal study of young people in England (LSYPE) data, for instance, revealed there to be a strong class and ethnic dimension in teachers' decisions regarding track placements and tiered entries within the UK.[74]

System

Curriculum

The national curriculum is a good example of a structural education system as an influencing factor. At this high level, even small changes with regards to adding, removing or editing STEM content could have a significant impact on educational choices and career pathways. For example, engineering is not currently part of the primary school curriculum. Consequently, experts we interviewed were keen to see more research into the impact of outreach in primary school age children, in part with a view to informing potential changes to the curriculum. There were, however, concerns that primary school activities should not be a replication of secondary school activities and programmes, and should be tailored based on the factors that influence young people at each age.

Another possible barrier to STEM participation may be the requirement in most UK schools to specialise in either the 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.

Cultural norms and sterotypes

Stereotypes of what an engineer looks like can also affect young people's desire to pursue the profession as a career. Research by the Institution of Engineering and Technology found that among a representative sample of children aged 9 to 16, a typical engineer was described as a white (51%), male (67%), with a hard hat and a high vis jacket (40%), laptop and a mobile phone (40%), or using protective eye wear (39%) and carrying a toolbox (37%).[75] Such views suggest that there is a poor understanding of the variety of opportunities engineering can offer. They also may serve as a deterrent for those who do not fit this stereotype, since the less a young person feels a sense of belonging or feeling of fit within a field, the less likely they are to pursue it.[76]

The TISME[77] programme of research found that many middle-attaining students enjoy mathematics or science but see science careers as only for the 'brainy few'. Related to this, and as discussed previously in the gender section, is that groups who are traditionally underrepresented in post-16 physical sciences tend to be less likely to identify themselves as being 'good' at science or mathematics, irrespective of their actual abilities and attainment. It has been argued that the widely-held perception that certain STEM subjects are only for 'geeks' or 'nerds' is perpetuated and frequently reinforced by the media.[78] Research conducted by a team from Stanford University showed that exposure to commercials featuring sexist stereotypes (e.g. women as sex objects, in support roles for a male protagonist, or doing domestic chores) caused women to avoid maths questions on an aptitude test and to show less interest in maths-related education and career opportunities[79]. On a more positive note, another study found that people who were shown representations of women as computer professionals were more likely to view this profession appropriate for women.

The influence of mass media matters because children spend a lot of time watching and interacting with media. There are countless opportunities across different media channels to influence young people towards or against STEM career pathways. For young children, most media consumption time involves watching television. As children grow up, they start spending more and more time on their phones and on the internet. Once children reach their early teenage years, they spend over 20 hours per week online.[80]

Changes over time

An important finding from *Determinant of Aspirations**Error! Bookmark not defined.**,* an extensive review of the literature by Gutman and Akerman, was that aspirations are not fixed—they adapt and change in the light of new experiences, choices and information. Initial aspirations start to form at a young age (certainly by age 11, and possibly younger), and tend to decline as children mature, in response to their growing understanding of the world, and to constraints imposed by previous decisions and achievements. The decline in aspiration is particularly steep for those facing multiple disadvantages—for example, children born to teenage parents.

School subject choices are key points in the engineering career pathway. To get on an engineering degree course, prospective students will typically need to have opted to take mathematics A-Level and at least one other science-related subject (most typically physics), which in turn is linked to GCSE-level choices prior to that. As noted by Poskitt in a 2016 paper, these decisions 'occur during adolescence—a period of intense identity formation, strong emotions, living in the moment, and peer affiliation—characteristics which may affect decision making.'**Error! Bookmark not defined.** In addition to normal adolescent issues, young people now also have to contend with the 'always on' virtual world of connected devices and social media.

Previous attainment is known to be a major factor in determining future subject options and choices. Many students with a low grade in maths GCSE are discouraged or prevented from taking A-Level maths. Even pupils with middle-high grades in STEM subjects might be more inclined to pursue other subjects in which they achieved relatively higher grades.[81] Therefore, the time periods before and after when young people take exams are likely to be particularly important. The ages for exams in England are as follows:[82]

- Ages 5–7: tests in reading, writing and maths. Teacher assessment looks at speaking, listening and science skills as well as the areas covered by the tests.
- Age 11: tests for English, maths and science prior to moving to senior school.
- Age 14: tests for in English, maths and science. Teachers assess pupils in these areas plus art, citizenship, design technology, geography, history, ICT, MFL, music, PE.
- Ages 15–16: GCSE exams.
- Ages 17–18: A-Levels.

There are various differences in Scotland that should be taken into account. One key difference is that in Scotland, children are assessed throughout their primary and secondary school years when the teacher feels the child will achieve that level. This differs to SATs in England, where the whole class will sit an exam at the same time that covers a range of levels, and be awarded one of the levels within the range.

The experts we interviewed for this review thought that more could be done to influence primary age children. The transition between primary and secondary school was also considered to be a critical timepoint in young people's education journey.

Teenagers experiencing strong emotions and living in the moment are thought to be particularly open to 'automatic' influencing factors described in behavioural economics. These relate to how decision-making often involves using heuristic shortcut strategies to form judgements. Framing effects, for example, suggest that young people might be 'nudged' towards particular subjects, depending on the default options or how the choices are presented. There have also been cautious suggestions that 'present bias'—the tendency to overvalue short-term rewards at the expense of long-term goals—could be increasing the proportion of young people choosing easier courses over harder subjects with better long-term prospects.[83] The implication here is that interventions aimed at reducing present bias during the subject choice period could potentially increase the proportion of young people choosing STEM subjects.

Section B: What Works

There is still much to learn about why a career in engineering is not appealing to many young people. However, the problem is relatively well-understood when viewed in comparison with what we can say about the solutions. Although there are initiatives to strengthen the evidence base of The 'what works' – with the Education

Endowment Foundation, for example, offering grant funding for such research – it remains a sparse evidence base, particularly in relation to STEM outreach. Outreach encompasses a diverse range of interventions (fairs, workshops, mentoring schemes, clubs, field trips, competitions, and so on[84]) and there is little evidence available about which activities are the most or least effective. Most evaluations involve light-touch, self-reported feedback surveys which report on positive experiences and attitudes—but it is risky to extrapolate from a spike in claimed STEM interest to long-term changes in subject and career choices.

The lack of evidence does not mean we can say that STEM outreach has no impact, but it does mean that the sector needs to get better at measuring outreach effectiveness. Such concerns were vocalised by experts across the education sector. Our conversations highlighted concerns that the sector largely operates in siloes and is focused on developing an organisation's own approach to outreach, rather than a focus on the impact of such delivery methods. There is a tendency to emphasise engagement with outreach and short-term positive attitudes towards STEM, and a lack of evidence about whether this persists or supports young people into STEM education or careers. Experts urge for more coordination within STEM outreach and wider educational outreach and better impact practice across the sector.

So, what can we say about what works? The most consistent theme is that **prolonged engagement has been found to be more effective than one-off initiatives.** This finding, based on evidence from Nuffield, Gatsby, Ofsted and others, and referenced in WISE's *Not for people like me* report (2014)[13], has important implications for the allocation of limited resources. Focusing on engaging with a smaller number of young people over a longer period of time is likely to be more effective than reaching thousands of children with one-off events. Another report from 2014, a study which evaluated three STEM outreach interventions in Norway, also concluded that development of the initiatives over time and prolonged 'exposure' with participants were important factors in the effectiveness of STEM outreach activities.[85]

Banejee, an academic from Exeter University, has run two effectiveness evaluations of STEM outreach programmes involving science practical lessons; ambassador visits; and trips to laboratories, STEM centres and higher education institutions.[86] The first longitudinal study used mathematics grades at GCSE level and the second used subject choice at the end of Key Stage 5. While mathematics grades and subject choice are not the only indicators worthy of investigation, they are important markers of likely future success in STEM careers. The study concluded that the grades and subject choices at the schools receiving the outreach activities were not statistically different from the grades at the control group schools. The implications from these findings are that further research is required to test the effectiveness of current practices and new interventions.

That said, there is some evidence that relatively light-touch interventions can have significant effect on educational outcomes. For example, in a randomised control trial of 650 students in their GCSE year, Education and Employers found that those who received three extra career talks were more likely than their peers to report improved attitudes and motivations to studying and to outperform their predicted grades.[87] It was however noted that this intervention was most effective for lower achievers and less engaged learners.

The Brilliant Club, a university access charity, is another good example of a programme successfully linking interventions to high-level impact outcomes. The organisation arranges for people doing PhDs to share their academic expertise with state schools with the aim of increasing the number of pupils from underrepresented backgrounds progressing to highly selective universities. For three years running, analysis by UCAS showed that pupils on The Brilliant Club's Scholars Programme were significantly more likely to progress to a highly selective university than pupils with similar socio-demographic background and GCSE attainment.[88]

However, there is some evidence to suggest that to combat against entrenched issues, such as gender stereotypes, sustained intervention is needed. The *Notes for Teachers* report from the Ada Lovelace Network is one such report that argues that one-off interventions are not long enough to overturn the cultural biases that are stacked against girls, and 'do not sufficiently improve girls' confidence, resilience, and ability to accurately assess their own skills.[89] In particular, the report argued that interventions that depend upon competition may even damage girls' confidence.

Existing literature also suggests that **a one-size fits all solution may not be possible: some interventions may be more effective for some groups than others.** For instance, there is some evidence that girls are more likely than boys to prefer collaboration over competition.[90] The Ada Lovelace Network report goes on to discuss why this might be the case, hypothesising that when boys lose a competition they are likely to carry on and try again, whereas girls, who typically have lower confidence in their STEM abilities, may walk away feeling that the loss is an indication that STEM is not for them. Demographic analysis of citizen science participants reinforces this point: competitive “first to discover” projects such as *Supernova Hunters* are heavily male-dominated, whereas more collaborative projects such as *Arizona Batwatch* or *Mapping Change* tend to have a fairly even gender split.[91]

It has also been suggested that more could be done to combat real or perceived elitism within the STEM sector. One of the Aspires report findings was that science is aligned with the concept of innate ‘cleverness’. The report concluded that certain young people, particularly girls, find it hard to recognise themselves as being naturally clever. They instead see themselves as working hard, which is perceived to be the opposite of being naturally clever. Archer, one of the authors, went on to state that: ‘We cannot leave institutions like engineering or physics untouched in their elite-ness and just expect to widen participation, we have to give up some privilege and make it less special if we want to widen participation.’[92]

Other studies have similarly noted the need to **make interventions as inclusive as possible**. Research by Nesta, for example, hypothesised that competitions might be encouraging young people to win rather than to learn, and recommended that competitions should be designed to promote equity, meaningful educational experiences, and long-term outcomes for communities.[93] The report went on to conclude that good practice involves: designing outreach interventions with the most disadvantaged groups in mind (current provision is skewed towards more privileged schools); ensuring that the activities are related to young people’s own experiences; and setting time aside for both participants and providers to reflect on any learning, and to integrate this into future programmes.

Research published by the Education Endowment Foundation put forward **three variables that have proven to be successful in increasing science learning**[94]. These are:

1. scientific reasoning: the ability to understand how causal variables should be isolated and varied independently from each other in experiments

2. literacy: reading comprehension is a longitudinal predictor of science attainment, possibly because it helps with reading scientific texts and understanding scientific vocabulary

3. metacognitive ability: the ability to think about your own cognitive abilities

The report concluded that interventions and training in these areas can have a positive effect on science attainment. There were also some interesting insights in that report in terms of which age groups to target. Analysis of the UK National Pupil Database identified two points in pupils' school career when the gap in science attainment increases: at about 5–7 and 11–16.

The RCUK School-University Partnership Initiative found that there are **better outcomes for young people when outreach activities are co-designed with teachers and embedded and sustained over time.**

In practice, understanding what works in STEM outreach is not only important for the impact on young people, but is also crucial for teachers when deciding their career support programmes. Experts consistently raised that the lack of evaluation across outreach support makes it challenging for teachers to understand which programme will make a difference.

Section C: Knowledge Gaps

Given the scarcity of evidence about what works, it is hard to know where to focus on research investments. Arguably the most pressing gaps in the evidence base are quantitative impact studies linking STEM outreach activities (and counterfactual comparison groups) with objective, long-term measures such as subject choices, grades and career choices. Without that sort of high-quality evaluations, we will never be sure which interventions are working. Science is one of the key themes of the Education Endowment Foundation so it is likely that some of the gaps in this section will addressed in the coming years.[95]

In terms of age groups, the largest gap in the STEM outreach evidence base is primary school-level research. Research on early years and primary-level education suggests that formative experiences can play a big part in shaping young people’s educational attitudes, aspirations, and achievements, yet evaluations conducted to date appear to mainly focus on the choices made in middle and upper-school in relation to GCSE, A-Level and post-18 education and career options. We know comparatively little about the effectiveness of STEM outreach amongst 5–12 year-olds. A key consideration here is the time-lapse between primary school interventions and the main outcomes of interest (i.e. grades and subject or career choices). With smart data linking, researchers should be able to track outcomes over long periods, but other shorter-term outcomes (e.g. expressed interest in STEM subjects and careers) should be considered. Experts were also keen for research to explore influence in primary schools, including the transition period to senior school. With older children, there were calls for more evidence about the effectiveness of outreach activities outside of traditional academic routes, such as T-levels and apprenticeships.

Other notable evidence gaps include measuring the impact of engaging other actors in the wider system. For example, we know parents are important influencers in young people's decisions, and that some organisations like Nuffield are running sessions with parents, but we can't say if or how STEM outreach organisation should be engaging with parents. We also know very little about the impact of peer-led initiatives or social media outreach.

The existing evidence base lacks concrete examples of negative impact. We know from other youth intervention fields that well-meaning behaviour change programmes can be harmful. A well-known example is the "scared straight" type of programme which takes young people on prison visits with a view to putting them off a life of crime. These interventions have been found to *increase* the likelihood that the young people will be convicted of a crime. Similarly, an Australian infant simulator programme, designed to prevent teenage pregnancies by giving young people robotic babies who cry in the night and need their nappies changing, was found to *increase* teenage pregnancy rates.[96] In education, there is reasonably reliable evidence that repeating a year at school is harmful.[97] With the wide array of STEM outreach activities taking place, it is statistically probable that one or more types of STEM intervention may be doing more harm than good, but we are currently unaware if this is the case. Robust impact evaluations are required to identify harmful policy and practice, and to make the case for diverting resources to more promising activities that can help engineering deliver greater economic and societal benefits. The need for including counterfactuals understanding the unintended consequence of activities was confirmed during our expert interviews.

Another potential area to explore is understanding the relative importance and impact of outreach intervention content and values. A theory put forward by Louise Archer is that getting the mindset, values and mission of the outreach organisation right is more important than the content of the intervention or what types of activities are involved. Well-performing examples from related fields include Hanwell Zoo in West London, a world-leader in community involvement and conservation education. Another example is Knowle West Media Centre, a charity in Bristol supporting people to make positive changes in their lives and communities, using technology and the arts to co-design creative solutions and explore new ways of doing things.

Looking more holistically, little is known about the extent to which greater coordination between outreach activities could improve outcomes. A view expressed in the expert interviews was that STEM outreach organisations are effectively in competition, both with each other and with other outreach sectors. As a consequence, it was felt that many activities are quite isolated, and the lack of progression of activities across primary and secondary schools makes it difficult for schools to navigate and build a package of opportunities as young people grow. It seems highly plausible that greater collaboration among outreach organisations, the education sector, and the wider communities would result in better user journeys and outcomes for young people, but with the present evidence base, this is hard to prove.

The gender imbalance in the sector makes it very important to understand what works for girls. Any future evaluations must, where possible, report on the impact of gender differences. With the deep-rooted cultural barriers around girls choosing to work in professions like engineering, holistic "system change" approaches could be an especially fruitful area for further research. The impact of the gender, relatability and communications skills of the people running STEM outreach programmes is another gap. Research by the Royal Academy of Engineering hypothesised that poor training and communication skills on the part of the outreach intervention leaders could be doing more harm than good by discouraging prospective engineers.[98] Gender inequality within engineering could also be reducing the effectiveness of outreach activities. This is a quote from an engineer involved with school outreach, who was interviewed for the above-mentioned Royal Academy report:

"There is a huge shortage of positive female role models in engineering. The first problem is that not enough women go into the profession. The second problem is that so many women drop out of engineering, and those that tend to stay have had to masculinise themselves in order to get on." – Female engineer, 29

If that quote is indicative of the sector at large, it is perhaps not surprising that many young girls don't consider engineering is for 'people like them', even after meeting female role models from the industry. In an interview conducted as part of this project, Louise Archer made the connecting point that presenting female champions as unique in some way also perpetuates the problem, as it contributes to the idea that engineering is for the special few, and not for 'normal' people.

Outside the STEM sector, a collaborative taskforce is currently creating the "Future skills framework" to highlight future 'essential' workplace skills people will need in the future. This can be used across all subjects and aims are to help people, to understand what workplace skills will be needed in the future, and to help employers hire criteria and training opportunities.

Section D: Current Evaluation Approaches

Most STEM outreach evaluations that we have seen tend to focus on short-term feedback measures such as satisfaction with the event or activity and attitudes towards careers in STEM. Experts are keen to see more longitudinal data-tracking where possible. One expert suggested such short-term evaluation practices are in part due to the expectations of funders in the sector. There is a lack of clear understanding of what good impact and evaluation looks like. They urged funders to be clear about what good outcomes look like, consider allocating a higher proportion of budgets to research and reflection, and to collaborate more with other funders to create a culture of learning and more longitudinal tracking of outcomes.

It is also important to recognise that impact upon an expansive objective, such as cultivating the engineering talent pool, is not something that can be measured at one point or in isolation, but rather something incremental and the result of myriad efforts over time. To fully understand whether STEM outreach is having its intended impact, evaluation efforts will need to somehow account for the fact that a young person may participate in a range of activities over the course of their life (for example, by seeking to measure these or by making appropriate provisions in sampling).

A useful way to categorise the current evaluation approaches is to see how they fit into *Five Types of Data*', a classification described by James Noble, Measurement and Evaluation Principal at New Philanthropy Capital. The five types of data are as follows:

Data Type	**Description**	**Examples**
User data	Service user characteristics	Gender, ethnicity, socioeconomic status, interest in stem careers
Engagement data	The extent to which people engage with the service and how they use it	Outreach service reach, types of outreach activities, attendance frequency
Feedback data	What people think about the service	Satisfaction with the service, aspects they liked/disliked, ideas for improvements
Outcomes data	The immediate effect of the service on knowledge, attitudes and behaviour	Short-term changes in STEM career knowledge, perceptions of STEM subjects
Impact data	The long-term difference on individuals, families and communities	School subject choices, grades, university course enrolment, employment statistics

STEM outreach evaluations tend to focus on the first four types of data. Engagement data appears to be particularly well covered. For example, the *STEM Learning Impact Report*[99] provides comprehensive coverage of their reach, delivery and activity data, and comparatively little on the other types of data. Those first four types of data are useful for to support the development of an intervention (formative evaluations) and to assess the facilitators and barriers to successful implementation (process evaluations).

The fifth category, impact data, is the most difficult and resource-intensive type of data to collect, so it perhaps not surprising that this data is rarely collected. However, impact data is often considered to be the most valuable type of data. Sharing reliable evidence about the relative effectiveness, and cost-effectiveness, of different types outreach activities, is the only way the sector will ever be able to collectively shift resources away from low-impact activities and invest more in the most impactful types of programmes. To demonstrate the extent to which more reliable impact data could reshape the intervention landscape, it is helpful to look at the broader evidence base about the proportion of interventions which make a statistically significant difference. In 2015, the Arnold Foundation published a review of randomised controlled trials (RCTs are widely regarded as the most robust method of evaluating the effectiveness of interventions), looking across various social programmes and found that , unfortunately, most social programmes have little or no impact.[100] The review included the findings that 90% of the education interventions commissioned by the Institute of Education Sciences since 2002, and 75% of the employment and training interventions commissioned by the Department of Labour since 1992, were found to have weak or no positive impact.

The fact that most interventions do not have a positive long-term impact is not a reason to give up. It simply emphasises the importance of identifying the minority of interventions which do make a positive (or negative) difference. STEM outreach is certainly not the only sector lacking sufficiently long-term impact data: the same problem can be found in research exploring the impact of interventions in homelessness, children's social care, and crime reduction. However, the relatively systematic education and employment data collection infrastructure already in place (exam results, UCAS reports, etc) arguably makes it easier, at least in theory, to start joining the dots between STEM outreach activities and the long-term impact on individuals, schools, communities, and the engineering sector. A high awareness of research methods and standards of evidence across the sector should also help to enable the spread of good evaluation practices.

Collecting good quality impact data requires a long-term commitment to investing in research. Depending on how 'upstream' the intervention is, it could be a long wait before high-level impact data (education attainment, employment status, etc.) can be analysed. The long-term impact of a science outreach programme in primary schools, for example, may not become fully apparent until the subject choices and grades data is captured at GCSE level. By this point, there is also a chance that the underlying social and educational environment will have changed – so there is a risk the evidence could be out of date. STEM outreach in the UK includes a diverse and numerous range of programmes.[101] Many of the smaller programmes will likely struggle to afford or justify investing in capturing meaningful impact data on their own. As noted in the Research Council's guide for evaluating public engagement activities, outreach providers should consider whether the cost and effort of the evaluation method are proportionate to the activity.[102] Established practices with a solid evidence base will likely need to be evaluated less robustly (and less frequently) than newer, more innovative programmes. Collaborating with others to form a shared vision and evaluation plan could help to reduce the burden on the individual organisations and help to foster a culture of shared learning and improvement.

Conclusions and initial recommendations

The state of the STEM outreach evidence base needs to improve. Most evaluations of STEM outreach activities lack reliable long-term impact data, so we can say very little about what works. A good strategy at the sector level would be to reduce the overall number of evaluations being conducted and consolidate the available research resources into delivering a smaller number of higher-quality evaluations. Evaluations should seek – where possible - to capture higher level longitudinal outcomes such as STEM subject choices and exam results. In terms of the actual outreach activities, the evidence again suggests that taking a sustained approach, and engaging children over several years, is likely to be an effective strategy, as is taking into account the fact that some interventions may work better for some groups than others. A necessary first step towards building that long-term evidence base is to agree, at a sector level, a shared language to clarify what is meant by terms like 'engineer' and 'reliable evidence', and a shared vision for what success looks like.

Appendix

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