TEN SCIENCE FACTS & FICTIONS:

The Case for Early Education about STEM Careers

Overview

Science, Technology, Engineering and Mathematics (STEM) are vital for the economic and cultural life of the UK. Ensuring high levels of scientific literacy across the general public and an appropriate supply of STEM professionals for the future is crucial – and how this is approached must be based on the most substantial and reliable evidence available.

This document summarises current, high-quality, international research evidence from the fields of science and mathematics education and makes recommendations for change. Through the presentation of ten 'facts and fictions', we make a case for the pressing need to integrate an awareness of STEM careers into the mainstream school curriculum. We believe this will help increase young people's understanding and engagement with STEM, both at school and in later life. Our discussion primarily addresses the education system in England, but has points of relevance for other countries.

Evidence is drawn from international research literature and new findings from a major, 5-year longitudinal research study, funded by the Economic and Social Research Council, currently being conducted in England (the ASPIRES project[1]).

Fact or fiction?

01 'Liking science is not enough'

02 'Science is only for the most able'

03 "If I do science, I have to be a scientist"

04 'Children think all scientists are geeks'

05 'It is very hard to change people's stereotypical views of science'

06 'One-size-fits-all approaches to STEM careers education are sufficient'

07 'Artistic children don't choose science'

08 'Boys are naturally more interested in the physical sciences than girls'

09 'You can never start careers awareness too early'

10 'Science is a route to social mobility'

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ASPIRES

Science and career aspirations: age 10:14

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‘Liking science is not enough’

FACT:

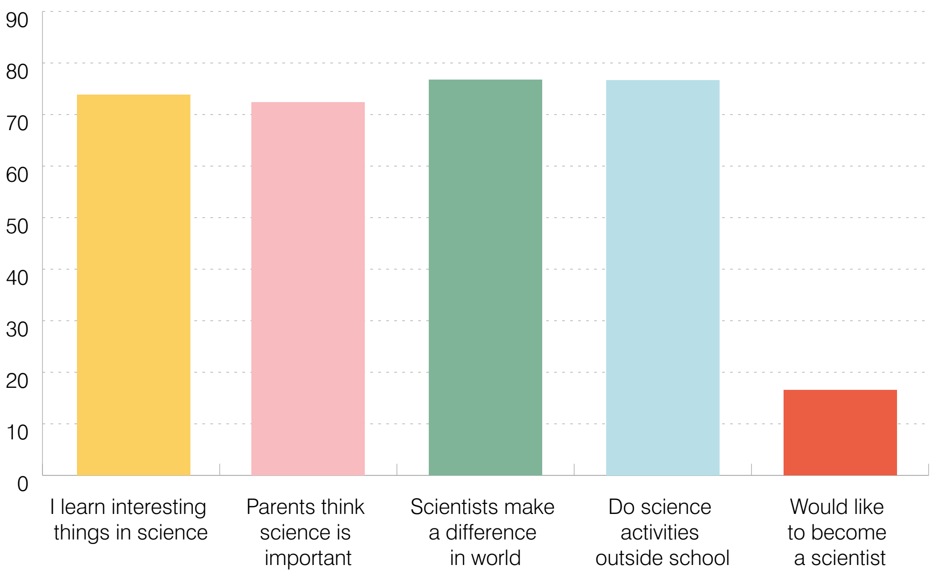
Evidence from a UK survey of over 9,000 pupils aged 10/11 shows that even though the vast majority of children at this age enjoy science at school; have parents who are supportive of them studying science; hold positive views of scientists and even undertake science-related activities in their spare time; nevertheless, very few (less than 17%) aspire to a career in science[2]. Studies also indicate that, after the age of 10/11, children's science attitudes start to decline (notably from ages 10-14)[3] with a further diminishing of science aspirations. Consequently, it would seem that even from a young age, many pupils may not envisage continuing with science post-16 as it does not fit with their future aspirations.

Thus increasing participation in science at higher levels is not simply a matter of increasing young people's interest in science or making it more ‘fun’. There is a disconnect between interest and aspirations, with research showing that even those who enjoy science and do well, can decide from an early age that science is ‘not for me’. Research shows that young people's aspirations are strongly influenced by their social backgrounds (e.g. by ‘race’/ethnicity, social class and gender) and family contexts[4], where identity and cultural factors play an important role in shaping the perception of science as ‘not for me’[5].

Consequently, more needs to be done to make science a ‘conceivable’ career option for a broader range of pupils, such as incorporating explicit teaching about STEM-related career opportunities into Key Stage 3 lessons.

Although there is an intrinsic value in ensuring that children are engaged by academic subjects at school, the potential for raising participation rates through making subjects more ‘fun’ is far from clear-cut. International comparative data[6] suggests that the relationship between enjoyment of a subject, attainment and participation rates is highly complex and varies considerably between nations. For instance, countries with high attainment and participation rates in mathematics (such as Japan) also record amongst the lowest levels of student liking for the subject.

Fig. 1:
Percentage of 10/11 year olds in England agreeing or strongly agreeing with statements



'Science is only for the most able'

FACT & FICTION:

Evidence suggests that science is widely perceived by children and parents as 'hard' and scientists are associated with 'cleverness'[7]. These associations contribute to science careers being seen as different, unusual and 'not for me' from an early age – even before the end of primary school[8]. Currently careers in and from science are not commonly perceived as 'for all', which discourages many children from developing science aspirations.

Despite some useful reforms in national science curricula to broaden the nature, content and appeal of taught science at GCSE level (e.g. through growth in vocational learning routes and apprenticeships), it seems that not all courses are afforded equal status. The most prestigious school science qualifications (e.g. 'Triple Science') are still those which are seen as the most academic and demanding[9]. Moreover, the current range of post-16 science qualifications remains exceedingly narrow and works against broadening participation. For instance, there are few post-16 science qualification routes for those who do not wish to follow the traditional A Level route[10].

Science education policy has been strongly criticised for assuming that its primary importance is to prepare the next generation of the nation's professional scientists (the 'science pipeline' model)[11]. Critics emphasise that the scientific literacy of the public is an equal, if not more, important goal of science education[12] and argue that it is questionable whether this goal is reflected in the current narrow range of post-16 science routes.

STEM plays a crucial role in national wealth creation[13], but evidence suggests that the 'pool' from which future scientists are drawn remains too narrow (especially in the physical sciences)[14]. For instance, even highly able individuals (notably women, working-class and some minority ethnic learners) can find it difficult to envisage themselves as 'science people', particularly when their backgrounds do not 'fit' the public profile of the wider science workforce[15]. A shared policy commitment to 'science for all' could help attract more diverse talent to help STEM fulfil its national economic remit.

Currently careers in and from science are not commonly perceived as 'for all', which discourages many children from developing science aspirations.

"If I do science, I have to be a scientist"

FACT & FICTION:

Although there are a wealth of career opportunities from science, evidence shows that children in both primary[16] and secondary[17] schools in England tend to conceive of science as leading to an extremely limited range of careers (notably scientist, science teacher or doctor)[18]. This lack of knowledge of the breadth of careers in science appears to be affecting science aspirations and participation rates. This issue is particularly acute for families with little 'science capital' (i.e. qualifications, knowledge, connections and interest in science)[19], and who are particularly likely to be from White and Black working-class backgrounds. The existing research evidence makes a strong case for more work to be undertaken to:

- **a** increase levels of science capital in an increased and more diverse range of families;
- **b** integrate awareness about the breadth of careers from science into the primary and secondary curriculum
- **c** publicise how science and mathematics qualifications 'keep options open' rather than closing them down. That is, **more children and families would benefit from understanding that science and mathematics qualifications have a strong exchange value in the education and labour market and are not purely specialist routes leading to a narrow range of careers in science.** Indeed, evidence suggests that science and mathematics can be highly transferable qualifications in the job market, with demand set to increase[20], but many young people and families are unaware of this.

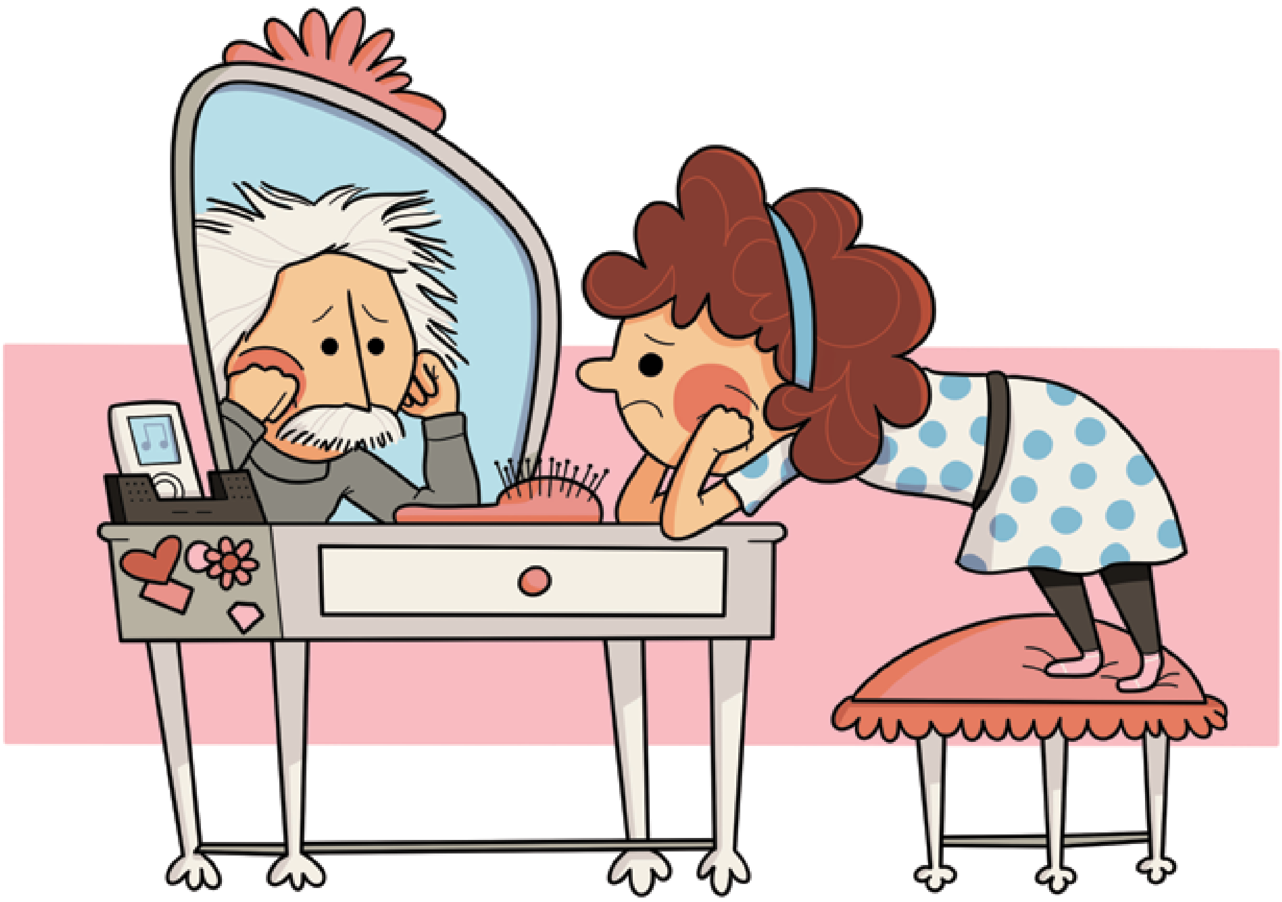
Useful work is currently being undertaken to provide teachers and schools with appropriate resources to help them in communicating these messages[21].

‘Children think all scientists are geeks’

FICTION:

Research shows that children and their parents hold quite complex views of science and scientists and that at age 10/11, these views are largely positive[22]. For instance, scientists are associated with doing important work (such as finding medical cures) that is often well paid. However, this research also shows that even positive stereotypes can be problematic and can lead to people seeing science as ‘Other’, only for the exceptional, and ‘not for me’. Prevalent popular associations of science with cleverness can make it seem out of reach for many and can feed into, and sustain, more negative stereotypes, such as science as being for geeks/nerds[23].

While most children are able to see beyond the ‘wild-haired, white-coated’ scientist stereotype, they still only recognise a very small number of ‘famous’ scientists, who are overwhelmingly white men such as Einstein and Newton or TV personalities such as Sir David Attenborough and Professor Brian Cox (with very few women and/or minority ethnic scientists identified).



'It is very hard to change people's stereotypical views of science'

FACT & FICTION:

Evidence suggests that the factors influencing young people's views of science are complex and that the relationship between their views of science and the likelihood of their participation is also far from straightforward. For instance, research shows that while most children express views such as 'anyone can do science', these views seem not to translate into personal choices to study science[24]. Research[25] also tells us that young people's views of science and their science aspirations are not just 'rational' (e.g. determined by a logical calculation of available information or based on an impartial assessment of one's abilities). Rather, they are highly influenced by personal experiences and a range of emotional, identity-based and cultural factors, which shape what 'feels right'. This often means that people's views can be resistant to change. It also means that simply providing alternative (or 'positive') stereotypes and images of science and scientists is often insufficient for changing people's behaviour, choices and aspirations. However, evidence shows that approaches can be successful in changing people's understandings where in-depth work is done with young people to enable them to deconstruct stereotypical, traditionally held views and ways of seeing the world[26].

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'One-Size-Fits-All approaches to STEM careers education are sufficient'

FICTION:

Research evidence shows that the way in which educational information is presented matters – and that educational decision-making processes can vary dramatically between different social groups[27]. Children and their families have differential access to, and make differential use of, particular forms of knowledge. For instance, **the presentation of 'cold'[28] (formalised, abstracted) knowledge on its own (e.g. through documents, prospectuses, the internet) is not always sufficient to change patterns of educational choice, particularly in the case of working-class learners. Working-class families tend to give more weight to 'hot' (interpersonal, 'grapevine') knowledge, particularly from known and trusted sources[29]**. Middle-class families tend to benefit from possessing much greater 'science capital' to assist them in making educational choices and tend to be more skilled and adept at making use of 'cold' information. This suggests that working more broadly with young people, their families and social networks (rather than solely targeting children as individual, de-contextualised, information processers and decision-makers) may provide a more useful way of 'growing' science aspirations and helping young people to perceive careers from science as conceivable and achievable.

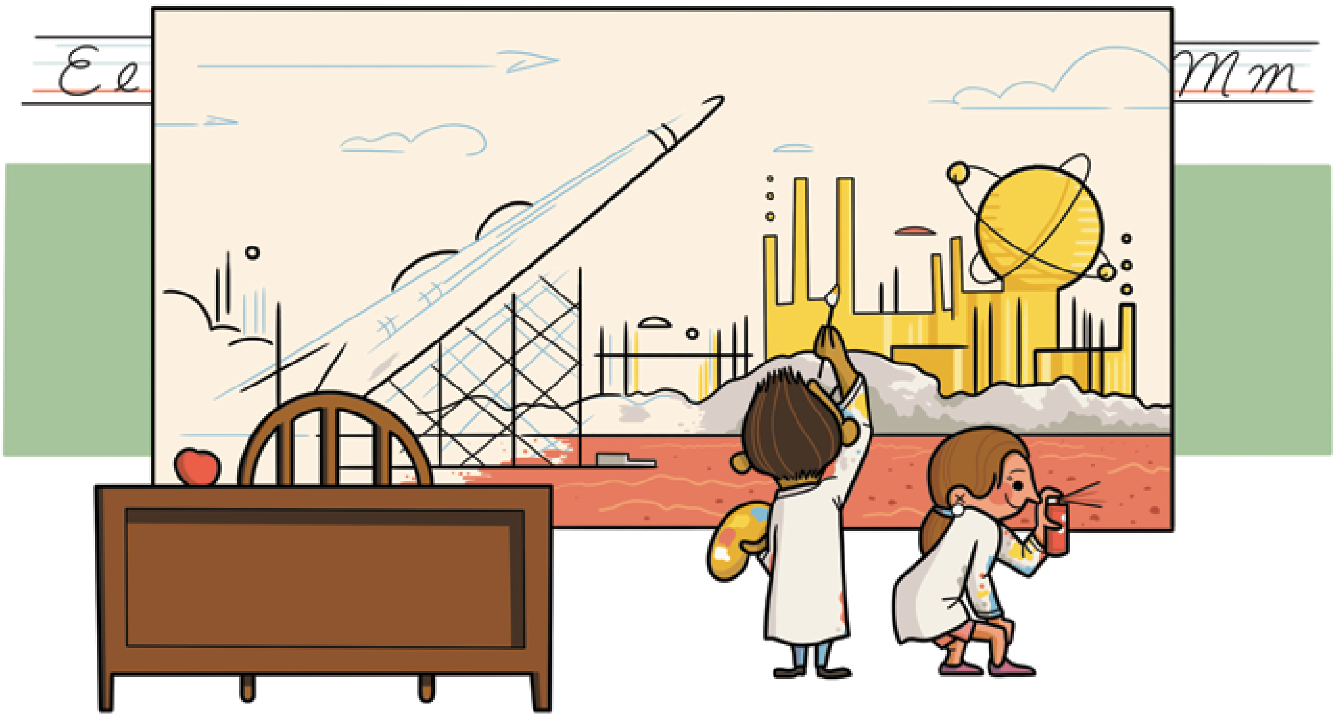
Evidence is emerging to suggest that appropriately structured and supported interactions – sensitive and tailored to the locality and diversity of individuals concerned[30] – can be effective. Such approaches emphasise the importance of going beyond a simplistic engagement with 'role models' or 'mentoring'[31]. Increasing engagement between young people and the wider world of work – through ambassador schemes, work placements and wider engagement between education and employers – can provide young people with direct knowledge, experiences and connections about particular careers areas and can translate into improved employment and earning outcomes[32]. Such collaborations between schools and external agencies could also usefully explore ways of enhancing children's and families' science capital and science career aspirations.

‘Artistic children don’t choose science’

FACT & FICTION:

Evidence shows that from an early age children and parents perceive an arts vs. science divide, which C.P. Snow famously termed the Two Cultures. Even in cases where children may be interested in and adept at science, family perceptions of them as ‘arty’/’creative’ can encourage these children not to see a career in science as attractive or ‘for me’. England has a particular culture of specialisation (with sciences being seen as highly specialised routes, antithetical to ‘the arts’) that would appear to contribute to lower post-16 science participation rates, as compared to other national contexts where there is a culture/ tradition of taking a more ‘rounded’ set of subjects (e.g. Scotland). Although the extent of actual divisions between the arts and sciences is a moot point (for instance, various organisations are committed to demonstrating the scope for creativity within STEM; and there are numerous careers which combine arts/ design and STEM expertise), popular public discourses in England maintain a fairly rigid divide, which contributes to a channelling of children’s aspirations from a young age.

While legislating to ‘force’ young people to follow particular educational routes can create an ‘army of reluctant conscripts’[33], moves to encourage a more ‘holistic’ culture within English education (combining both breadth and depth) would appear overdue.



'Boys are naturally more interested in the physical sciences than girls'

FICTION:

Gender patterns in subject interests have been shown to be socially constructed, not biologically based[34]. Evidence also suggests that families, teachers and schools play a part in creating gendered patterns of subject choice through, for instance, differential encouragement of boys and girls to pursue science[35]. Research provides examples of teachers favouring boys and perceiving them to be 'better' (and more 'naturally able') at science than girls, even where attainment data indicate otherwise[36].

In addition, it has been shown that even quite subtle differences within classroom cultures can profoundly shape the extent to which particular pupils (e.g. girls, minority ethnic pupils) feel that they are able to 'identify' with science (e.g. to see themselves as a 'science person'), irrespective of academic ability and the science curriculum[37].

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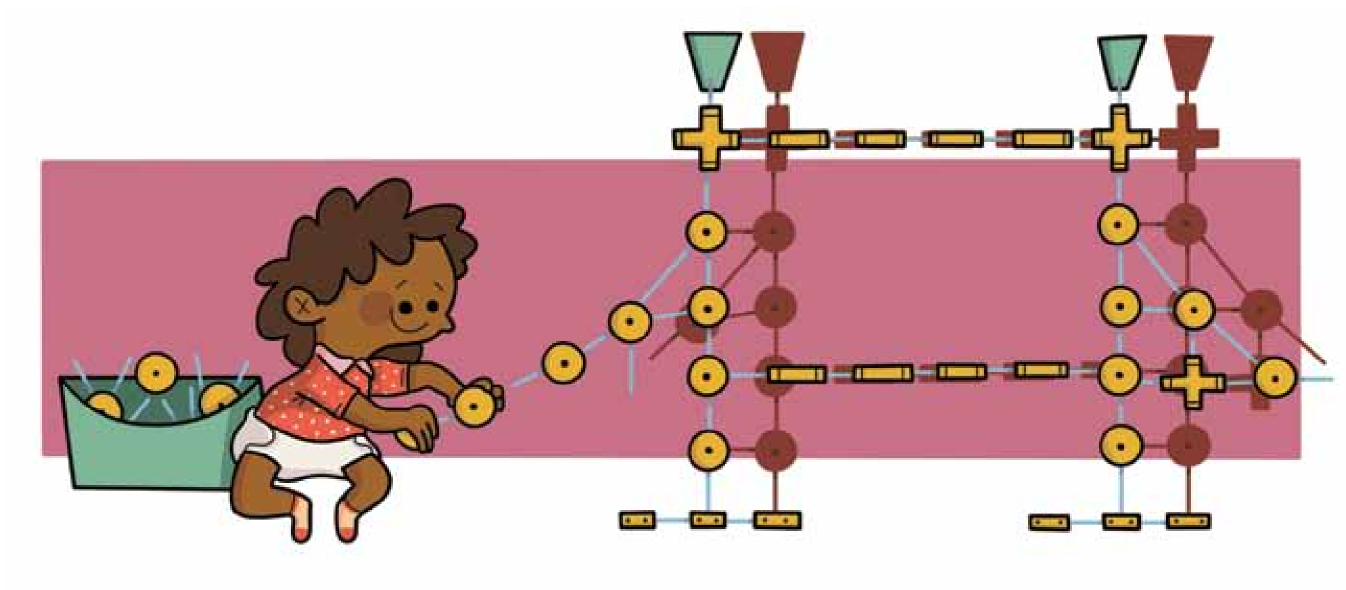
09 FACT OR FICTION?

'You can never start careers awareness too early'

FACT:

Evidence suggests that most young people's science aspirations and views of science are formed during the primary years and have solidified by the age of 14, by which point the idea of science as 'not for me' becomes very difficult to change[38]. There is a strong research case for starting to integrate awareness of careers from science into the primary curriculum. This is NOT to advocate 'careers advice' or 'careers counselling' for this age group – rather, a case is made for the embedding and integration of knowledge, information and awareness about careers in and from STEM across the primary and secondary curriculum. This is especially important given findings that even by age 10/11, when most children have generally positive views of science, the majority have already ruled out careers in science as 'not for me'. Research suggests that the narrow views of careers in/from science expressed by primary school pupils continues to be shared by adolescents in secondary school[39], again highlighting the importance of increasing young people's understandings of the breadth of careers from science from an early age. That stereotypical views of science appear not yet to be 'hardened' at primary school age, provides another impetus for directing attention at this age group.

Given the wealth of evidence suggesting that 'one-off' interventions have little long-term or widespread impact on science choices and participation rates[40], **research points to the potential value of a more sustained, longer-term programme to integrate science careers awareness into the mainstream science curriculum**, to highlight both the breadth of careers from science and the relevance of science to so many areas of everyday life. Such a planned approach to developing an embedded STEM careers awareness would necessarily involve (appropriately trained and supported[41]) subject teachers, high quality resources, linking to inter- and extra-curricula areas, and wider access to expert advice and guidance 'for all'[42]. It is also important to ensure that children understand how what they learn in science lessons is relevant and connected to their existing knowledge, other areas of the curriculum and their current and future lives.



‘Science is a route to social mobility’

FACT & FICTION:

While science careers can provide a path to social mobility (and are explicitly valued as such among some social groups), evidence shows that many parents and pupils do not see science as accessible and ‘open to all’[43]. Official statistics show uneven patterns of science participation across social groups, particularly within the physical sciences and at higher levels, where women and those from working-class and/or certain minority ethnic backgrounds (e.g. Black Caribbean) are severely under-represented[44]. Children’s early aspirations are also patterned by social class and ethnicity, with those holding science aspirations being disproportionately likely to come from middle-class and White or South Asian backgrounds[45].

Research indicates that much more can be done to make the culture of science, the curriculum, and young people’s experiences of taught science more appealing and inclusive while maintaining its rigour[46]. Many studies suggest that more needs to be done to encourage a greater diversity of young people and their families to perceive science careers as possible and achievable routes to social mobility. As discussed in this document, evidence indicates that this will require action on multiple fronts – working with students, teachers, schools, families, higher education, scientists and employers.

Research indicates that much more can be done to make the culture of science, the curriculum, and young people’s experiences of taught science more appealing and inclusive while maintaining its rigour.

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