Department for Education

# Applying Behavioural Insights to increase female students' uptake of STEM subjects at A Level

## Research report

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Government Social Research

# Contents

## List of Tables

## List of Figures

# 1. Executive Summary

Female students are much less likely than their male counterparts to take A levels in certain STEM (Science, Technology, Engineering and Maths) subjects. This is problematic for gender equality but also limits the country's capacity to address the growing national STEM skills shortage. This research was commissioned to design and test the effectiveness of two sets of interventions based on behavioural insights theory, to increase the number of high-achieving female students choosing STEM subjects at A Level.

The principle mechanism by which the interventions sought to increase uptake of STEM A Levels was by improving perceptions of STEM's utility – this was the target of the parent-focused intervention, as well as two of the three student-focused intervention exercises. The secondary mechanism was designed to improve students' self-concept and expectations of success in STEM. These interventions were based on insights from a rapid review of relevant academic research in the fields of psychology and behavioural science.

Participating schools received either a student-focused intervention in isolation, or the student-focused intervention in combination with a parent-focused intervention. While schools were free to administer the interventions to any and all students approaching their A level choices, the interventions were primarily intended for girls who were likely to be eligible to take STEM subjects (referred to as 'high-achieving girls' below).

The primary evaluation compared students' responses before and after taking part in the interventions (Pre-Post study design). The key findings after the interventions, as compared to before, are:

- High-achieving girls were more likely to state the intention to study two or more STEM A Levels.
- This positive change was greater for high-achieving girls in schools that received the parent-focused intervention in addition to the student-focused intervention.
- High-achieving girls were more confident that they could apply the material they learned in maths or science class to real life.
- High-achieving girls were slightly less confident in their ability to learn the material they covered in maths or science and that they could be successful in these subjects
- High-achieving girls were less likely to report having discussed the importance of maths or science with their parents in the previous month.

- Students who received the parent-focused activities showed an increased likelihood of discussing A Level choices with their parent or guardian, relative to those who received the classroom-focused activities only.

Following further evaluation of the data, the following additional findings were observed:

- There was a strong relationship between the intentions of girls to study STEM subjects with their final A Level choices.
- However, not all stated intentions to study STEM A Levels translated into formally-submitted A Level preferences (as was also the case for non-STEM A Levels).

As the design of the intervention was changed ahead of the administration to schools (from a Randomised Control Trial (RCT) to a Pre-post study design), it is possible that factors besides the interventions themselves were responsible for the changes in students responses after participation compared to beforehand. Further research would be required before firm causal conclusions can be drawn. Given the positive indications of the interventions, especially in tandem, such further research is warranted.

This report also seeks to make recommendations based on the efficacy of the interventions to inform further research and more broadly, to help develop targeted actions to improve diversity in STEM participation.

The recommendations are:

- That the observed benefits of the parent-focused activities in improving intentions of students to discuss A Level choices is studied in conjunction with existing careers guidance available in schools.
- That further research using the parent-focused intervention is also explored, including broadening the type of communication parents receive as this places no burden on teaching time.
- That capital-related inequalities and the action-intention gap are considered when carrying out further research.
- That any changes presented by the impact of COVID-19 on STEM uptake (compared to other subjects) in the coming years are explored, with respect to how changes in teaching e.g. remotely or in smaller class sizes would have affected student cohorts in England.
- That the focus shifts to the longer-term effects of societal norms surrounding STEM and perceptions about the challenges of the subject matter itself and interventions are targeted much earlier, particularly for girls.

# 2. Background

## 2.1. The Challenge

The Social Market Foundation (2017) found that the profile of jobs in the UK is changing and roles which require Science, Technology, Engineering and Mathematics (STEM) skills will rise at twice the rate of other occupations between now and 2023, creating a particular demand for graduate level STEM skills (NAO, 2018). STEM graduates are already in short supply and the number of students taking STEM-related courses decreases as students progress through the educational pipeline. Furthermore, the challenges presented by the SARS-CoV-2[1] epidemic in conjunction with the already existing need to respond to the challenges of an increasingly technologically advanced world (BEIS, 2017), put STEM careers at the forefront of skills demands.

The challenge to fill these posts will continue to grow unless more work is done to foster a pipeline of young people with STEM expertise. This will require understanding what works to encourage groups that are historically underrepresented to consider STEM, most obviously girls and women. For instance, Engineering UK (2019) found that only 12.0% of workers in engineering occupations were female despite comprising 47.1% of the overall UK workforce in 2018.

Despite outperforming boys in most GCSE STEM subjects[2], girls are choosing other subjects over STEM at the first opportunity. A Levels (or alternative post-16 pathways) represent the first point at which students choose whether to proceed with STEM subjects, opening or closing opportunities to pursue STEM subjects in Higher Education or as a career path.  At this point, gender disparity in the uptake of STEM subjects starts to emerge. In 2019, female students accounted for 44% of all STEM A Level[3] exam entries: representing just 13% of examination entries in computing, 22% in physics, and 39% in mathematics[4]. Importantly, relatively few girls opt for two or more STEM subjects at  A Level (22% of girls vs. 35% of boys in 2019, with only 10% girls vs. 18% of boys taking 3+ STEM subjects[5]), which is a requirement to access many STEM degrees.

In addition to contributing to the national STEM skills shortage, women's underrepresentation in STEM fields also presents problems in terms of gender equality and diversity. As our society becomes increasingly dependent on technology, STEM jobs grow in terms of income, status, and influence as well as number; it is important that these jobs are not overwhelmingly held by a limited section of society.

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[1] This research was undertaken prior to the epidemic.
[2] In 2019, with the exception of physics - DfE, Key stage 4 performance 2019 (revised) (link)
[3] For the purpose of this research, STEM A levels were defined as Maths, Further Maths, Physics, Chemistry, Biology and Computer Science
[4] 2019 Revised A level subjects by characteristics, DfE statistics: 2018-19 A Level results (revised) (link)
[5] 2019 Revised maths and science tables, DfE statistics: 2018-19 A Level results (revised) (link)

Girls have the potential to access STEM subjects and these subjects open doors to careers that are in-demand and well remunerated[6]. While it has been found that comparative STEM advantage explains at least 12% of the under-representation of qualified girls in the earliest instance of STEM specialisation (Goulas, 2020), the gender gap in STEM A Level uptake cannot be fully explained by traditional economic theories. Behavioural science has the potential to complement traditional economics explainations and help us to further understanding the barriers to participation and identify appropriate solutions.

## 2.2. Research Aims

The target behaviours for the present research were:

1. Increasing the number of girls choosing maths A Level
2. Increasing the number of girls choosing two or more STEM A Levels

The goal was to develop interventions, informed by behavioural insights, that could have an immediate impact on the number of girls who would go on to be eligible to apply to STEM degrees or career paths. As such, the present research sought to target the very next wave of students selecting their A Levels.

The research aims also align with the wider DfE goal of increasing maths A Level take-up and policies such as the Advanced Maths Premium, as well as the Smith Review target of increasing the number of students studying maths until the age of 18. Girls are not underrepresented uniformly in all STEM subjects and indeed in 2019, made up 63% of biology and 54% of chemistry GCSE entries respectively. There are also a larger number of female (65%) than male (35%) graduates from Biological Sciences for instance at higher education[7]. While there are issues further up the chain in postgraduate research and indeed in employment, this research focuses on improving the pipeline at A Level.

Additional requirements of the present research were that the interventions had a strong link to Careers Advice, Information and Guidance, be considerate of school workload, and be scalable, such that nationwide rollout would be feasible and affordable. Furthermore, the present research was to include a robust evaluation, such that the impact of the interventions could be accurately determined.

[6] Higher Education Graduate Outcome Statistics: UK, 2017/18 (link)
[7] HE qualifications obtained by subject area and sex, HESA 2018/19 (link)

## 2.3. Rapid Evidence Review

The Behavioural Insights Team conducted a rapid review of evidence relevant to the research aims, to investigate the factors contributing to the gender gaps in STEM A Level uptake and to identify interventions to encourage girls to consider STEM options.

### 2.3.1. Why is there a gender difference in STEM A Level uptake?

A number of academics have looked at this question through the lens of 'expectancy-value' theory (Eccles, 2019). According to this theory, the courses that a student selects depend on their 'expectancy-value' assessments of the available options. Expectancy refers to the student's expectations of success. Value refers to the extent that the student values the option in terms of (a) its usefulness for fulfilling personal goals ('utility value'); (b) the extent to which it matters for the student's sense of self or identity ('attainment value'); (c) how much the student actually enjoys it ('intrinsic value'); and (d) the costs associated with the option, including social, psychological and economic costs, as well as the opportunity costs of alternatives ('costs').

These expectancy-value motivational beliefs are influenced by the individual's experiences, which will be affected by the culture in which the individual lives (Eccles, 2015). In particular, gender-role socialisation will shape these beliefs. However, this does not necessarily translate across to all STEM subjects. Archer (2020) found that biology A Level students, are three times more likely to be female than physics students and one and a half times more likely to be female than chemistry students. There is an association of science with 'masculinity and cleverness' but this was particularly pronounced in the case of physics compared with chemistry and biology (Archer, 2020).

#### 2.3.1.1. Expectancy

Girls' expectations of success in STEM subjects relative to others appear to be lower than those of boys even though their performance is no worse (Wang, 2013).

- Poor STEM self-concept

Despite girls outperforming boys in most STEM subjects at GCSE[8], they are less confident in their abilities in STEM (Wang, 2013). This is likely due to stereotypes about STEM and gender. STEM subjects (particularly some, such as physics) are seen as being only for people who are very 'brainy' (Archer, 2020), and internalised gender stereotypes about brilliance discourage girls from engaging in such activities; girls as young as six endorse the notion that genius is an exclusively male trait (Brian et al.,

[8] DfE, Key stage 4 performance 2019 (revised) (link)

2017). There is also a specific stereotype that girls are less naturally talented in STEM than boys (Eccles, 2015).

A factor that may contribute to poor STEM self-concept in some cases is stereotype threat; this is the threat experienced when you perceive that your behaviour may be viewed through the lens of a negative stereotype. The stress and anxiety it brings can make it harder to perform well (Miyake, 2010).

Beliefs about the nature of intelligence are also important here; if people believe that STEM ability is innate and fixed, then current perceptions of low ability in STEM will necessarily mean low expectations of success in the future.

- Cross-domain comparisons

Girls' expectancy-value beliefs about non-STEM options are also relevant. Where girls have higher expectations of success, or assessments of their own abilities, in non-STEM subjects (Skaalvik, 1990), this will make them more inclined to choose those options. Gender stereotypes will influence girls toward this viewpoint. Furthermore, there is evidence to suggest that it is more common for girls to demonstrate high verbal abilities as well as high maths abilities (Wang, 2013), meaning that, among students eligible for STEM A Levels, the girls are more likely than the boys to be drawn in other directions. There is also evidence, discussed in the section below, that perceived abilities in non-STEM subjects could negatively impact self-concept in STEM.

- Parents and teachers

Parents and teachers both influence girls' belief in their ability to succeed in STEM subjects. Parents' beliefs about their child's abilities in a given subject predict those of the child, even when controlling for teachers' assessments (Eccles, 2015). And, importantly, parents' beliefs are influenced by the gender of their child; even when girls outperform boys in both maths and English, parents are more likely to think sons are talented in maths than daughters, and vice versa for English (ibid).

Furthermore, there is evidence that the better a parent thinks their child is at English, the worse the child thinks they are at maths. Girls' self-confidence in maths is more likely to suffer via this mechanism than boys', because girls are more likely than boys to be thought of as being good at English by their parents (ibid).

Similarly, teachers are more likely to attribute girls' success in physics to 'hard work' and boys' success in physics to being 'naturally bright', even when they do not perform as well as girls (Archer, 2013). There is also evidence that teachers stereotype maths as a male domain and consider girls to have lower ability in the subject than boys (ibid). Differential teacher expectations for achievement translate into differential treatment of students. Importantly, the more a teacher stereotypes maths as a male domain, the more strongly their students endorse the maths gender stereotype (Keller, 2001).

#### 2.3.1.2. Value

Girls' perception of the personal value of STEM subjects relative to others is lower than that of boys (Eccles, 2015).

- Personal goals

A major factor that discourages students from choosing STEM is that they doubt the usefulness, or relevance, of STEM subjects for their lives (Archer, 2013). Girls are more likely than boys to endorse communal goals (e.g. working with or helping others) and there is a stereotype that STEM subjects do not help fulfil these goals (Diekman, 2011), with the exception of biological and other health sciences, in which females are not underrepresented.

Most young people have a narrow view of the usefulness of STEM subjects and where they can lead; for many young people, science qualifications appear to primarily lead to being a scientist, a science teacher or a doctor. Therefore, if a young person does not intend to pursue these roles, they are more likely to see post-16 science subjects as 'not relevant for me' (Archer, 2013).

- Social norms

Humans are social creatures and, as such, our behaviour is heavily influenced by our perception of what other people are doing, especially people who we consider to be like ourselves; we tend to follow suit. There is a perception that STEM subjects are more 'for boys' (Girlguiding, 2017) or as Archer (2013) posits, girls tend not to see these subjects as 'for them'. Girls do not see 'people like them' represented in STEM (Cassidy et al., 2018) and report a relatively low sense of belonging in STEM fields. STEM subjects do not align well with the stereotypical female gender identity (Archer, 2013) and there may be high costs for girls in choosing to participate.

- Cross-domain comparisons

Value judgements about non-STEM subjects are also relevant here, as an individual can only take a limited number of A Levels. There is evidence that girls may value non-STEM subjects more than boys do. For example, in a German study, girls were found to value English as a subject more than boys (Lauerrmann et al., 2015; Eccles, 2015). Girls are more inclined than boys to be interested in careers related to 'caring', human-services and the arts (ibid) and therefore girls are more likely to value school subjects that they see as likely to help them achieve these goals.

- Parents and teachers

Parents and teachers are key influencers of students' beliefs about the value of STEM for them (Harackiewicz et al., 2012). Students are much more likely to select post-16 maths and/or physics if a key adult - typically a family member or teacher - has conveyed to them the worth of the subject, along with the belief that they can do well in it (Archer, 2013).

However, teachers report limited knowledge about the range of STEM careers and research finds that most parents have narrow views about where science can lead (ibid). Furthermore, given parents' and teachers' biases to consider STEM a male domain, these influencers are less likely to encourage girls into these subjects (Newall et al., 2018). Indeed, recent DfE research (Ipsos Mori, 2019) found that parents/carers of boys are more likely to discuss careers in STEM with their child than parents/carers of girls (70% vs. 56%). Parents can share gender-stereotyped views of occupations with their children (Ikonen et al. 2017) and Tenenbaum and Leaper (2003) found that parents of daughters are less likely to believe that their child is interested in science.

### 2.3.2. What works?

Relatively little is currently known about what works to increase STEM course uptake as there have been very few rigorous evaluations of interventions with course choice as an outcome measure.

#### 2.3.2.1. Targeting students' utility perceptions

Nevertheless, a number of interventions have been shown to shift young people's expectancy-value beliefs about STEM or self-reported motivation to participate in STEM. Many of these have targeted students' perceived STEM utility. Some have provided students with information about STEM's utility (Durik, 2007) and others have invited students to make their own arguments for how the STEM subjects they are studying are relevant for their lives (Hulleman, 2010). This 'self-persuasion' is thought to be particularly powerful because it is less didactic and avoids compromising young people's autonomy, and because we are typically more readily persuaded by our own arguments, partly because they are tailored to our own interests and goals (Yeager et al., 2014). There is some evidence, published by Gaspard and colleagues (2015), that providing students with quotations from other students about the usefulness of STEM, and inviting them to evaluate the personal relevance of the quotations, might be the most effective strategy. This is likely because some students struggle with self-generating arguments about the personal usefulness of STEM. Furthermore, the other students, who provide the quotations, act as relatable messengers conveying the personal utility of STEM (Dolan, 2010).

Gaspard's intervention also sought to target girls in particular. It included information on: the relevance of STEM for traditionally female, as well as male, activities and careers; the importance of effort and self-concept for success; and the unhelpful frame-of-reference effects that can occur in the classroom - this is when people derive their STEM self-concept by comparing their performance to those of others in the class rather than to their own performance over time. The study's results showed some evidence of stronger effects on the perceived value of STEM for girls than boys.

Another intervention that was specifically intended to appeal to girls was designed to show how the career of a scientist can actually afford communal goals (Diekman, 2011). Girls were more positive about the career of a scientist when it was presented as involving more collaborative as opposed to independent work.

Similarly, an intervention designed to foster a 'self-transcendent' or prosocial purpose for learning has been shown to increase persistence with subjectively boring maths exercises and to increase attainment in STEM courses (Yeager et al., 2014). This intervention is referred to as a 'purpose for learning' exercise. It first primes prosocial thinking by asking students how the world could be a better place. It then uses statistics and testimonials from other students to create the social norm that 'people like them' are motivated to study in school because it will allow them to help others in the future. Finally, the intervention asks students to write a message to future students about their own reasons for studying; in addition to the benefits of self-persuasion described above, the act of advocating for a message helps people to internalise it.

#### 2.3.2.2. Targeting parents' utility perceptions

Judith Harackiewicz and her colleagues in the U.S. took a different approach: they developed an intervention that targeted perceptions of STEM's utility in parents. They found this intervention to have a significant impact on STEM course uptake in the high-school-age students (aged 15-18) of the targeted parents (Harackiewicz, 2012). The parents were provided with information, via brochures and a website, about the relevance of STEM subjects for a wide range of educational options and careers as well as daily life activities. Importantly, parents were also given guidance on how to talk with their child about course choices and help them to make connections between STEM and the things they really care about in their lives. In a randomised controlled trial, this intervention was found to increase the science and mathematics courses taken by students in the last two years of high school by, on average, nearly one semester (ibid). The study also conducted surveys and found that the intervention promoted mothers' perceptions of STEM's utility value as well as conversations between parents and their children about course choices, which, in turn, both contributed to improved perceptions of STEM's utility value in the students.

#### 2.3.2.3. Belonging

There is some evidence that relatable role models may have a role to play in encouraging girls into STEM (Drury, 2011; Van Camp, 2019). However, it appears to be very important that role models not conform to STEM stereotypes (e.g. being geeky and socially awkward) (Cheryan, 2011; 2013).

Another potential approach is the de-stereotyping of STEM environments; one study found that girls were more likely to express interest in studying computer science when shown a classroom that did not conform to STEM stereotypes compared to when they were shown a classroom that did (e.g. decorated with Star Wars posters etc.) (Master, 2016). This effect was mediated by an improved sense of belonging. However, this would not have been a practical option for the current project.

'Social-belonging' interventions (Walton, 2007; 2011; 2015) have been shown to increase academic course attainment amongst negatively stereotyped groups. These interventions use relatable messengers to create the social norm that everyone worries that they do not belong at first, but that this fades over time. The interventions also ask the students to contribute their own message for future students to help them settle in, thereby making them feel like the architects, rather than the recipients, of the intervention, and helping them to internalise the message. However, while these interventions have been shown to decrease course drop-out, there is little evidence for their efficacy in encouraging negatively stereotyped groups to *opt in* to potentially threatening environments. The same can be said for Values Affirmation exercises, which are designed to overcome stereotype threat by affirming one's sense of self outside the realm of academic study (Miyake et al., 2010).

#### 2.3.2.4. Expectancy

Despite calls to do so, relatively little attempt has been made to specifically target expectations of success in STEM, besides the intervention elements mentioned above (those designed to emphasise the importance of effort and self-concept and to discourage comparing oneself to others) (Gaspard et al., 2015).

An intervention that normalises the need to put in effort to achieve success on university STEM courses has been found to increase motivation in women (Smith, 2012). This study did not measure expectations of success but did find an increase in sense of academic belonging.

Forewarning activities have also been used to improve performance in STEM courses (Aronson, 2009). These activities inform students about the concept of stereotype threat, with the goal of helping girls attribute performance anxiety to this concept rather than their own abilities. However, as with the social belonging and values affirmation exercises, they are not typically used to increase course uptake, and their influence on attainment (in which there is no gender gap in STEM GCSEs in any case) may only be effective in scenarios where the negatively stereotyped group is a numerical minority (O'Brien et al., 2019).

#### 2.3.2.5. Conclusion

In conclusion, the evidence base particularly supports interventions that target perceptions of STEM's utility for fulfilling students' personal goals. Both interventions that target students directly, and those that target their parents, show promise. Girls are likely to be particularly receptive to interventions emphasising the ways in which STEM subjects can help achieve communal and altruistic goals. Relatable, and non-stereotypical, role models and messengers may also be helpful as well as attempts to increase girls' self-confidence and expectations of success in STEM subjects, for example through the normalisation of effort.

# 3. Interventions

The aim was to increase the number of girls choosing two or more STEM A Levels and to improve maths uptake. Based on the evidence, both a parent-focused and student-focused intervention were developed - each drawing on previous promising interventions in this space. The hypothesis was that by improving expectancy-value beliefs about STEM for girls and their parents the likelihood of girls choosing STEM subjects for A Level could be improved.

## 3.1. Student-focused intervention

A student-focused intervention was developed, which was a series of three exercises for students to do individually, on a computer, in a classroom setting. It was at each school's discretion when these exercises were delivered over the intervention period (February to April 2019), providing there was at least a week between consecutive exercises.

### 3.1.1. Expectancy exercise

The first of the exercises was designed to boost students' self-concept and expectations of success in STEM.

The exercise began with a brief context-setting introduction, emphasising the increasing importance and communal value of STEM subjects, and outlining the content of the upcoming exercise as an opportunity to support fellow students to achieve their potential as they approach GCSEs and decide what to do next.

It went on to explain that many students underestimate their abilities in STEM and that this holds them back from achieving their potential because self-belief is an important factor for success. It presented 'three lessons for achieving success':

1. Effort is the most important factor for success and everybody can improve;
2. Don't judge yourself against other people;
3. Track your progress in each subject over time and avoid comparing across subjects.

The exercise then explained that messages from fellow students can help people to believe that they can do well in STEM. It presented an example message. Finally, the exercise invited the student to write a message to help younger students believe in their ability to do well in STEM.

### 3.1.2. Utility exercise

The second exercise in the series, which was administered at least a week after the first, began with a brief recap of the first exercise.

Next, the exercise explained why it matters if someone wrongly believes that they are bad at STEM subjects or assumes that these subjects are not 'for them'; it makes them more likely to miss out on the benefits of continuing to study them after GCSEs. Then followed a summary of some of the key ways in which STEM A Levels are useful for university, jobs, making a difference and daily life.

The remainder of the exercise was based heavily on the quotation intervention developed by Gaspard and colleagues (2015). Quotations from other students about the usefulness of STEM A Levels for their own lives were presented. The students completing the exercise were asked to: reflect on whether they had heard similar arguments before; identify which of the quotations they can most relate to and why; order the statements in terms of personal relevance; and contribute their own statement about why STEM subjects are important to their life - an opportunity to self-generate arguments.

The exercise ended with a suggestion that the student talk to their parent/carer about the ways that STEM can be useful in life and the value of carrying on with these subjects after Year 11.

### 3.1.3. Purpose for taking STEM exercise

The third exercise, which was administered at least a week after the second one, was a version of Yeager's 'purpose for learning' activity, geared towards STEM A Levels.

The exercise started with a recap of some of the career opportunities to which STEM subjects can lead, including a number of examples that afford communal and altruistic goals. Next, survey statistics and testimonials from students about the reasons they chose to continue with STEM subjects at A Level were presented. These created the social norm that many students choose to study STEM at A Level because it will allow them to help people in the future. Finally, the students taking the exercise were invited to write their own testimonial (for future students) about how STEM A Levels could help them become the kind of person they want to be or make the kind of impact they want to have on the people around them or society in general.

At the end of the exercise, students were, once again, reminded to talk with trusted adults, such as their parents, about their A Level choices. They were invited to give the decision careful consideration, as it will affect their options later on, rather than going with their gut instincts or doing the subjects their friends are doing. They were encouraged to write down a few ideas of the people they are going to talk with, or things they are going to find out about, to help with their decision about what to study.

## 3.2. Parent-focused intervention

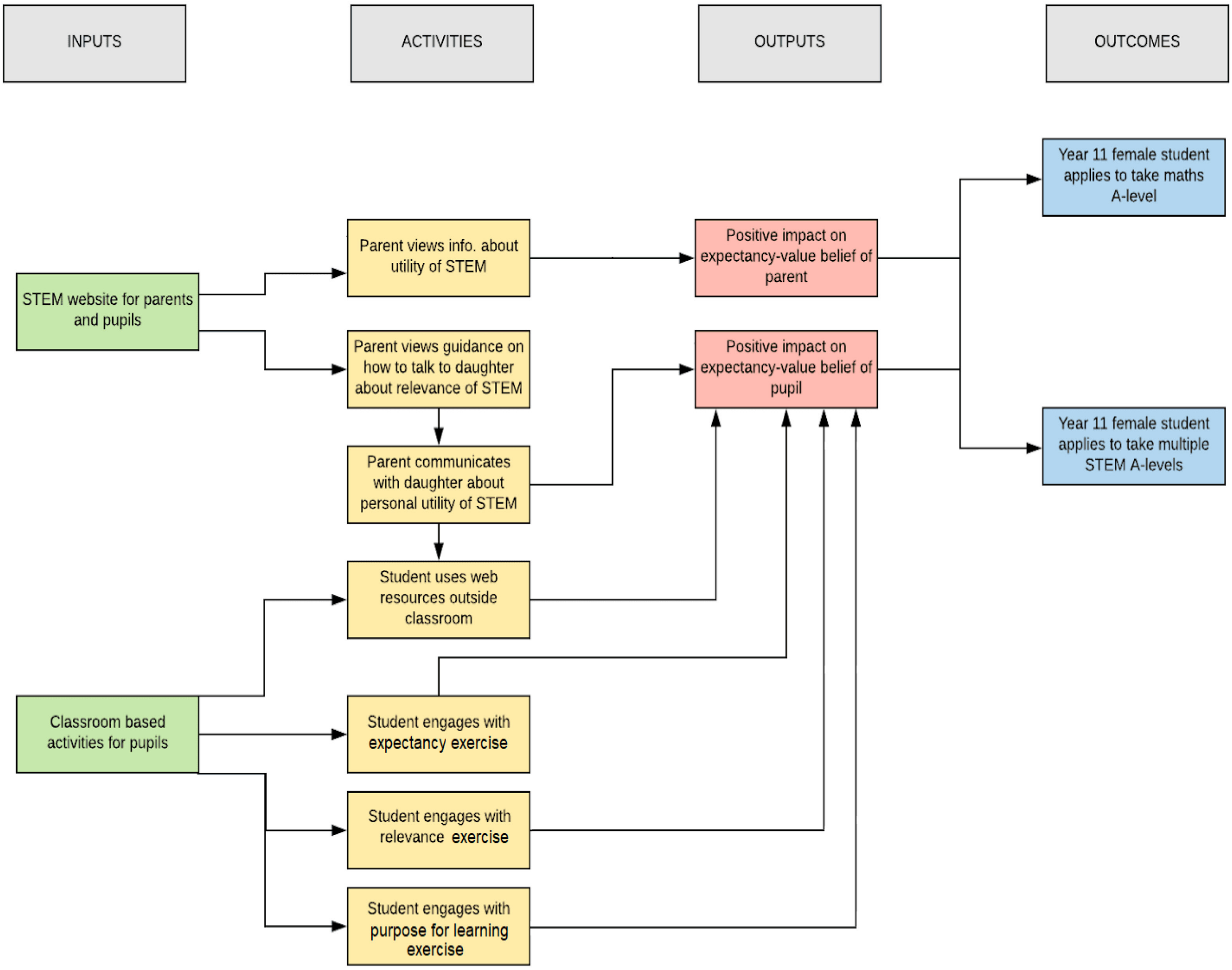
In collaboration with Judith Harackiewicz, a second, parent-focused intervention was developed, based on the one she used to increase STEM course uptake in the US, but adapted for the UK context. The intervention was a parent-facing website, which provided information about the usefulness of STEM A Levels for a wide range of educational options and careers as well as daily life. It also provided guidance for parents on how to talk with their child about A Level choices and how to support them to make connections between STEM subjects and their personal goals and interests. Notably, the website contained examples of how STEM subjects could help fulfil communal and altruistic goals, and hosted many images of students working together on STEM activities, including a large number of females who did not conform to stereotypes about the kind of people who work in STEM. One of the web pages also contained videos of students talking about the ways in which STEM A Levels had been relevant to their lives.

Parents received emails signed by an authority figure at their child's school, directing them towards the website.

The original intention was that these messages would also communicate their daughter's potential to do well in STEM subjects, thereby increasing expectations of success and perceptions of ability in STEM. However, following the trial design changes, the intervention was made available to all students not just high-achieving girls and the wording was adjusted accordingly.

Please see the Annex for the detailed intervention materials.

## 3.3. Theory of Change



# 4. Research Design

The final trial design was a pre-vs-post research design in which the student-focused intervention was made available to all students in the target year group at all participating schools, while half of participating schools were randomly allocated to also receive the parent-focused intervention. The primary outcome measure was students' intended A Level subject choices, as measured in a survey at the beginning and end of the series of student-focused intervention exercises. This was a shift from the initial design, which led to some implementation and evaluation challenges, described below.

## 4.1. Design revision

The original intention for this research was that the evaluation would take the form of an individual-level randomised controlled trial (a commonly-used trial design, including in the Behavioural Insights Team's previous work with the DfE[9]) with students' A Level subject choices as the primary outcome measure. In this design, once schools were recruited to the project, the girls who were soon to make their A Level decisions and were likely to be eligible for STEM subjects (based on predicted grades and schools' requirements - please see the 'High-achieving Girls' section of the Annex) would be randomly allocated to one of three conditions: 1) parent-focused intervention; 2) parent-focused intervention + student-focused intervention; or 3) control. During the classroom-based sessions in which girls in condition 2 completed the student-focused intervention exercises, girls in conditions 1 and 3, as well as the other students in the classroom, would complete control versions (designed to be visually virtually identical to the intervention exercises, but to concern physical health and screen time).

However, to ensure that provision did not vary within schools, a decision was taken not to proceed with an individual-level randomisation. Students/parents talk about what they are doing, which might have led to some sharing of the information and cross-contamination across groups. It was felt that excluding some students within a school from the intervention may have negatively impacted their expectation of success in STEM and it was important this was avoided. This decision meant that the evaluation strategy needed to be revised, but the timing of the decision limited the options for alternative trial designs; schools were expecting to receive interventions for their students and, indeed, had already scheduled the computer-based exercises, due to start within a matter of days of the decision. This meant it was not possible to have 'pure' control schools or to implement a stepped wedge design.

[9] DfE (2018) Improving engagement and attainment in maths and English courses: insights from behavioural research

Instead, the control student exercises were removed from the design and the DfE permitted schools to extend the student intervention exercises to all students in the year group, male and female, as they saw fit.

### 4.1.1. Primary evaluation: pre-vs-post

The primary evaluation was changed to a pre-vs-post research design. Survey measures were added to the beginning and end of the series of student-focused intervention exercises. The primary outcome measure became intended A Level subject choice, with expectancy-value motivational beliefs about STEM as secondary outcome measures. The measures collected after the last exercise were compared to those collected at the beginning of the first exercise to provide an indication of the effect of the interventions.

#### 4.1.1.1. Comparing the results for different treatments

All students involved in the trial received the student-focused intervention. Additionally, the parent-focused intervention was made available to just half of the participating schools for the trial period, randomly allocated **(please see the Annex for the randomisation balance checks).** This made it possible to compare these two intervention conditions (student-focused intervention only vs. student-focused intervention + parent-focused intervention).

However, it should be noted that this comparison was not properly powered because the power calculations that determined the target sample size were based on an individual-level (rather than school-level) randomised design. This means that null effects were likely for these analyses even if the parent-focused intervention did add value over and above the student-focused intervention.

#### 4.1.1.2. Implications of design revisions

The main consequence of moving from an individual-level randomised controlled trial to a pre-vs-post evaluation is that stronger assumptions are needed to interpret the results as causal impact of the intervention on the outcome.  This is because, in a pre-post analysis, the behaviour of girls observed *before* the intervention act as a counterfactual (or control) to the behaviour of the same girls observed *after* the intervention. This counterfactual suffers some limitation, as other factors may have changed before and after the intervention and may be confounded with it. For example, if students' stated intentions to take STEM A Levels had increased over the intervention time period, it is not certain that this would not have happened anyway.

Similarly, if stated intentions to take STEM A Levels had declined over the intervention period, it could have been that the interventions actually counteracted a steeper decline that would have happened in the absence of intervention. It is, in fact, quite easy to imagine that stated intentions to study STEM A Levels would decline over time: as students get closer to the actual decision point, they find out which subjects their friends are taking and they get advice from others e.g. about which subjects are relatively difficult at A Level. The causal interpretation of the results relies on assuming that no such changes would have happened, absent the intervention.

#### 4.1.1.3. Comparing the results for girls and boys

Another implication of opening the interventions up to all students, male and female, rather than targeting them at high-achieving girls, was that this may have limited the ultimate potential effectiveness of the interventions. Interventions could no longer reference students' particular potential in STEM subjects, as a means of boosting expectations of success. Furthermore, sixth forms may have a maximum capacity for their A Level classes. If the interventions encouraged boys to take STEM A Levels (and there is evidence (Harackiewicz, 2012) that the parent-focused intervention might be effective for lower-attaining boys but not lower-attaining girls) then this would have limited the number of slots available to more girls.

As the interventions were made available to both genders, whether girls and boys responded differently was also examined.

#### 4.1.1.4. Correlation between the intention to study STEM subjects and actual A Level choices

A correlation analysis was run to establish the extent to which students' intention to study STEM A Levels, as stated in the 'post' survey, predicted students' actual STEM A Level choices, as submitted to their school.

### 4.1.2. Secondary evaluation: cross-cohort

As a secondary evaluation, the A Level subject choices of the year group involved in the trial (the 'treated cohort') and the previous year group ('untreated cohort') within schools that had sixth forms were compared with one another. An increasing proportion of girls taking STEM A Levels could provide indicative evidence of the effect of the interventions. However, once again, as with the primary pre-vs-post evaluation, causal inferences is highly caveated for this analysis. It should also be noted that (a) this evaluation was not restricted to the high-achieving girls that were the intended recipients of these interventions and (b) the extent of the current year group that was treated was left up to the individual schools to decide.

**Please see the Annex for more information on assumptions and considerations.**

## 4.2. Sample and eligibility

The sample was all students about to select their A Levels (i.e., students in either year 10 or 11), and their parents, at a sample of state-funded mainstream English secondary schools.

While not the only recipients of the interventions, the analyses focused on a subgroup of high-achieving female students in these schools: these were the girls who were eligible for at least one STEM A Level subject according to their predicted GCSE grades and the school's requirements, where provided - **please see the 'High-achieving Girls' discussion within the Analytical Methods section.**

A subset of analyses focused on 'very high-achieving girls', defined, for the purposes of this project, as those predicted GCSE grades of 8 or higher in all their maths and science subjects.

The sample for the secondary (cross-cohort) analyses were participating schools with sixth forms.

The intervention trial period for this project was pre-specified as spring term 2019. Therefore, schools whose year 11 students had already submitted their A Level subject preferences prior to this period worked with year 10 students instead of year 11. This represented around 80% of the participating schools.

### 4.2.1. Sample size

89 schools were recruited to the study and returned a Memorandum of Understanding (MOU). Of these, 55 schools provided survey data on the intended A Level subject choices of their students before and after the exercises. This provided 3,872 students with a complete set of data on primary outcomes, 1,625 of which were high-achieving girls (those likely to be eligible to take at least one STEM A Level).

This represents a high level of attrition. Much of the attrition was related to schools' concerns around GDPR legislation. The 55 schools used in this analysis had an average pass rate (grade 5 or higher) in both English and Maths of 52%. This compares to 48% amongst the other 34 schools who originally signed up to the trial and 43% of all other mainstream state funded schools nationally.

47 schools provided data of the final A Level subject choices of their existing cohort, either through manual returns or via the online portal provided. Of those students that had a complete set of data on primary outcomes, 2,846 students' A Level choices were shared, 1,318 of which were high-achieving girls.

30 schools with sixth forms provided complete summaries of the A Level choices of their previous cohort too. These were used for school level modelling.

Please see the Limitations (section 7.2) for attrition-related discussions.

## 4.3. Outcome measures

### 4.3.1. Primary evaluation: pre-vs-post

Survey measures were collected at the beginning and end of the series of student-focused intervention exercises.[10]

The primary outcome measures for this evaluation were high-achieving girls' stated intention to study A Levels in:

- Maths
- One or more STEM subjects at A Level
- Two or more STEM subjects at A Level
- Physics
- Computer Science

(the latter two being the subjects in which girls are most underrepresented).

The secondary outcome measures for this evaluation were high-achieving girls' self-reported:

- Expectancy of success in STEM
- Perceived utility of STEM
- Discussion with parents about A Level choices
- Discussion with parents about the value of STEM subjects

Please see the Annex for these survey measures.

### 4.3.2. Secondary evaluation: cross-cohort

Students' A Level subject choices were shared by schools (for both the current and previous cohorts of students, in the case of schools with sixth forms). In some cases, schools chose to have their students complete a secure online survey of their A Level

[10] In case a large proportion of students did not make it to the end of the third exercise, A level subject choice intentions were also surveyed at the beginning of the third exercise. However, completion rates were acceptable at therefore the data from the end of the exercise was used for analysis.

choices instead. For the cross-cohort evaluations, the outcome measures were the proportion of girls (enrolled in the school for both year 11 and year 12) who had chosen to study A Levels in:

- Maths
- Physics
- Computer Science
- One or more STEM subjects
- Two or more STEM subjects

## 4.4. Trial procedure

**Table 1** Timing of intervention delivery

| Timing | Activity |
|---|---|
| Autumn 2018 | Schools recruited. |
| January/February 2019 | Schools provided baseline data required for identification of high-achieving girls.<br>Schools were randomly allocated to one of the two treatment groups: student-focused intervention only or student-focused intervention + parent-focused intervention. |
| February - April 2019 | All schools administered the student-focused intervention exercises to as much of the year group as they saw fit.<br>Survey measures for the primary evaluation were collected at the beginning and end of the series of student-focused intervention exercises.<br>Emails directing parents to the parent-focused intervention website were sent to parents of students in half of the schools. |
| Summer 2019 - February 2020 | Schools provided A Level subject choice data for the secondary evaluation |

# 5. Analytical Methods

The survey responses of students pre- and post-intervention were collected through a bespoke online platform and were joined with the baseline data provided by schools on the attainment and characteristics of students participating. While the interventions were open to all students, this analysis focused on the survey response of 'high-achieving' girls only (as defined in the annex).

In addition, all results were repeated on a subset of this group including only those girls receiving a grade 8 or higher in their Maths and Science subjects. This group is referred to as 'very-high achieving' girls in this analysis.

## 5.1 Calculation of the overall treatment effect

The overall treatment effect of high-achieving girls was determined using a pre-vs-post evaluation strategy. A series of student-level linear probability models was produced to test how the primary and secondary outcomes recorded differed before the first student exercise and after the third student exercise.

For each model, only students who provided a response both before and after the intervention were included. A dummy variable 'After Treatment' was created to capture whether a student's response was recorded pre-intervention (value of 0) or post-intervention (value of 1). Student level-fixed effects were applied to each of the models.

Including student fixed effects helps control for unobservable factors which are student specific and would normally remain constant across the time period of this study. Examples include, a student's work rate, overall enthusiasm for academic study and their teachers' style and skills. These comparisons of outcomes over time, within the same student, are only possible for students surveyed before exercise 1 and then again after exercise 3; this reduces the overall sample size of each model.

### 5.1.1. Primary outcomes

The primary outcomes of this analysis are high-achieving girls' stated intention to study STEM A Levels. Each of the five primary outcomes were converted to dummy variables, given a value of 1 if a student stated an intention to enter a subject(s) and 0 if they did not.

In this setup, a positive value of the 'After Treatment' coefficient represents an increased likelihood in high-achieving girls' intention to study that subject at the end of the trial.

### 5.1.2. Secondary outcomes

The survey measures for a student's 'expectation of success in STEM' and 'perceived utility' were based around their stated confidence in the following four statements:

- I know I can learn the material we cover in maths or science
- I believe I can be successful in maths or science
- I can apply what I learn in maths or science class to real life
- I think maths or science will be important to my future

Students were given the choice of one of six options, which were then converted to a numerical scale ranging from 1 to 6, detailed below:

- Strongly disagree =1
- Disagree =2
- Slightly disagree =3
- Slightly agree =4
- Agree =5
- Strongly agree =6

The regression models produced assume there is a linear relationship between the post-intervention dummy variable and the numerical scale of each outcome response. A positive value of the 'After Treatment' coefficient represents increased confidence in the statement post-intervention.

The final two survey questions aim to understand the impact of the interventions on parental conversations. These were:

- I have had at least one conversation with a parent or guardian about my A Level choices in the last month
- I have talked to a parent or guardian at least once about the importance of maths or science in the last month

The three possible responses, 'Yes', 'No' and 'Not Sure', were converted into a binary outcome for each regression. A value of 1 was given for 'Yes' and a value of 0 for 'No' or 'Not Sure'.

## 5.2 Comparing different treatments

The relative impacts of the two treatment groups were compared for all primary and secondary outcomes. As before, individual-level linear probability models were set up for each of the outcomes, with an additional dummy variable 'Parent-Focused intervention' now added. Schools who received only the student-focused intervention were given a value of 0, while those receiving the parent-focused intervention as well as the student-focused intervention were given a value of 1.

The decision to randomly assign treatment groups at a school level rather than a student level has increased the likelihood that students' responses to survey questions before the interventions will not be equally balanced between each group. The modelling follows a difference-in-differences design and aims to identify the relative change between each group.

To achieve this, an interactive term was included in each of the models, 'After treatment * parent-focused intervention'. A positive value for this coefficient highlights where the group who additionally received the parent-focused intervention have made a greater relative increase compared to the student-focused intervention only treatment group.

## 5.3 Comparing the results for girls and boys

After changes made to the experimental setup, boys and girls were both able to engage with the interventions designed. This allows us to test whether girls have responded any differently than boys have. Most schools provided information on the predicted grades of their boys as well as their girls; this allows us to restrict the sample to only high-achieving students who completed information on their intended A Level choices before and after receiving the interventions.

As before, individual-level linear probability models were set up for each of the outcomes, with a new variable introduced to denote the gender of each participant. The interactive term 'After treatment * Boys' measures the differential effect between the genders over time. A positive coefficient would highlight a greater increase in intended uptake post-intervention for boys when compared to girls.

## 5.4 Correlation between the intention to study STEM subjects and actual A Level choices

The primary outcome measures, girls' intention to study STEM A Level subjects, are based on the self-reporting of high-achieving girls in the pre- and post-intervention surveys. Schools were later asked to provide data on students' formally submitted preferences, once these became available. This allows us to test how closely correlated a student's intention to take a STEM A Level is with their formal choices.

A series of linear regression models were produced for all high-achieving girls who provided survey responses and final A Level choices. A student's chosen STEM A Level was used as the dependent variable and their stated intention to study that same subject was introduced as an independent dummy variable in the model. Other characteristic information was also controlled for in the model, including the year group of the student, their ethnicity and whether they had ever been eligible for free school meals (FSM).

## 5.5 Comparison of the treated year group with the previous, untreated, year group

Schools with sixth forms were asked to provide summaries of A Level choices of their previous cohort split by gender. This group, who did not receive any of the interventions, can be compared to those involved in the trial. Due to the way schools reported this data the analysis focuses on school-level comparisons and focuses on all girls rather than high-achieving girls only.

Our primary outcome variables were set as the percentage uptake of STEM A Level subjects at a school level. Linear regression models were produced using the variable 'Treated cohort' to identify difference between the two groups. School-level fixed effects were included, and the academic year of the cohort and school type were also controlled for. Only schools that supplied a complete set of data for both cohorts were included in this model; this reduced the sample to only 30 schools.

## 5.6 Assumptions

### 5.6.1. Comparing different treatments

Comparisons of the relative changes in outcomes of the two treatment groups are made using difference-in-difference modelling. Time difference in survey administration are used to capture the relative difference between each group over time.

This effect has causal interpretation only under the assumption that absent treatment, the difference between the two treatment groups (if any) is constant over time. Despite having randomised schools to receive either student only or student + parent intervention, there were some significant differences in high-achieving girls' survey responses at the start of the study. If, absent the intervention, the views of these girls naturally converged or further diverged over time, this change would be confounded with the relative effect of one intervention over the other. For this reason, results from this analysis should also be interpreted with *caution.*

### 5.6.2. Cross-cohort

In order to capture the effect of the treatment on girls' actual A Level subject choices, we compared the choice of girls in the current cohort to the choice of girls in the previous cohort in the same school. The effect measured in the secondary analysis (school level) has causal interpretation only under the assumption that:

- the within-school-composition of Year 10 and Year 11 students is constant across cohorts in terms of all the characteristics the researcher cannot observe (ability, maths skills, motivation, etc.),
- schools did not make any changes to the curriculum, the teaching staff, or in the teaching methods such that they could be confounded with the treatment,
- the effect of any external factors (media, public opinion) in students' A Level choices is the same for previous students and current students.

As such, the estimation of the effect should be interpreted with caution.

### 5.6.3. School-level randomisation balance checks

70 schools agreed to participate in the trial. Schools were successfully randomised to parent and student vs student only interventions **(Refer to Annex A)**.

### 5.6.4. High-Achieving girls

Girls who were on track to attain the prerequisite GCSE grades to be eligible for at least one STEM A Level subject from Maths, Further Maths, Physics, Biology and Chemistry were identified using the following method:

- Schools that sent students' predicted grades and A Level entry requirements (schools with sixth forms): For these schools, identification was straightforward. Whenever a predicted grade was accompanied with a +/- sign, it was rounded to the next integer (i.e., 5- and 5+ became respectively 5 and 6).
- Schools that did not send students' predicted grades but sent A Level entry requirements (schools with sixth forms): Using information from the sample of students with predicted GCSE grades, students' predicted GCSE grades were estimated based on their KS2 Maths and English scores, year group, ethnicity, gender and FSM status.
- Schools with sixth forms that did not send their A Level entry requirements: The mode requirement across the sampled schools for each subject was used. (Table 2)

**Table 2** Mode requirement of sixth form schools

| A Level subject | Mode requirement |
|---|---|
| Maths | 6 |
| Further Maths | 7 |
| Biology | 6;6 if double or 6 if single |
| Chemistry | 6;6 if double or 6 if single |
| Physics | 6;6 if double or 6 if single |

- Schools without sixth forms:

  The minimum requirement across the sampled schools for each subject was used. (Table 3)

**Table 3** Minimum requirement of schools without a sixth form

| A Level subject | Minimum requirement |
|---|---|
| Maths | 5 |
| Further Maths | 6 |
| Biology | 5;5 if double or 5 if single |
| Chemistry | 5;5 if double or 5 if single |
| Physics | 5;5 if double or 5 if single |

# 6. Results

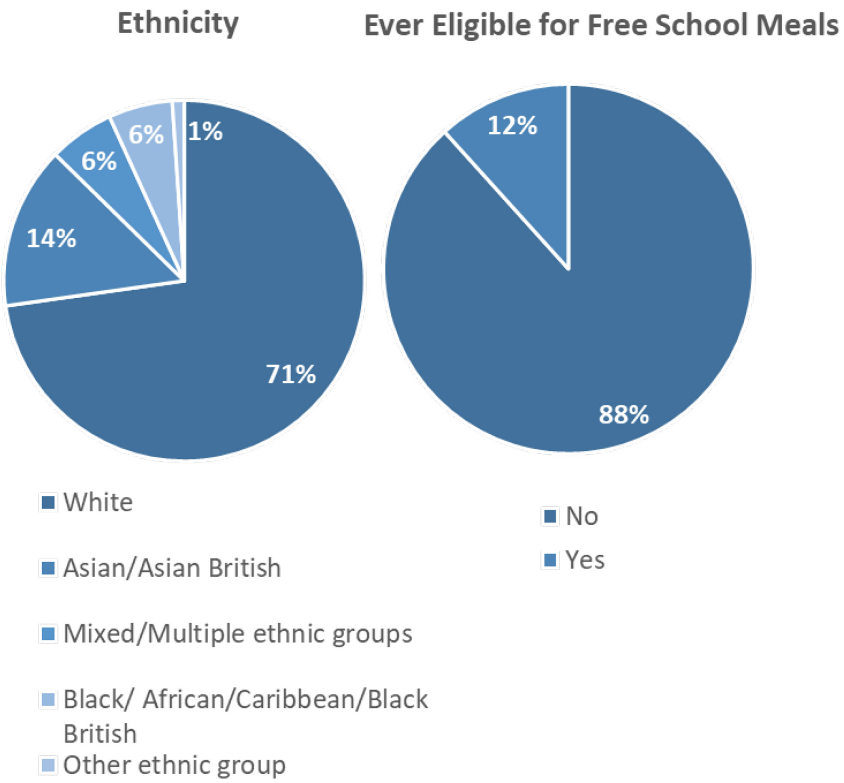
## 6.1 Descriptive data

### 6.1.1. Student characteristics

Figure 1 shows the demographics of the 1,625 high-achieving girls included in the analysis of primary outcomes. It shows:

- White students made up 71% of students within the sample; 14% were Asian, 6% were black, 6% were mixed and 1% other.
- In comparison nationally[11] 75% of students were white, 11% were Asian, 6% were black, 5% were mixed and 2% other.
- 12% of students were eligible for FSM within the sample compared to 27% of all students nationally.

**Figure 1** Characteristics of high-achieving girls sampled



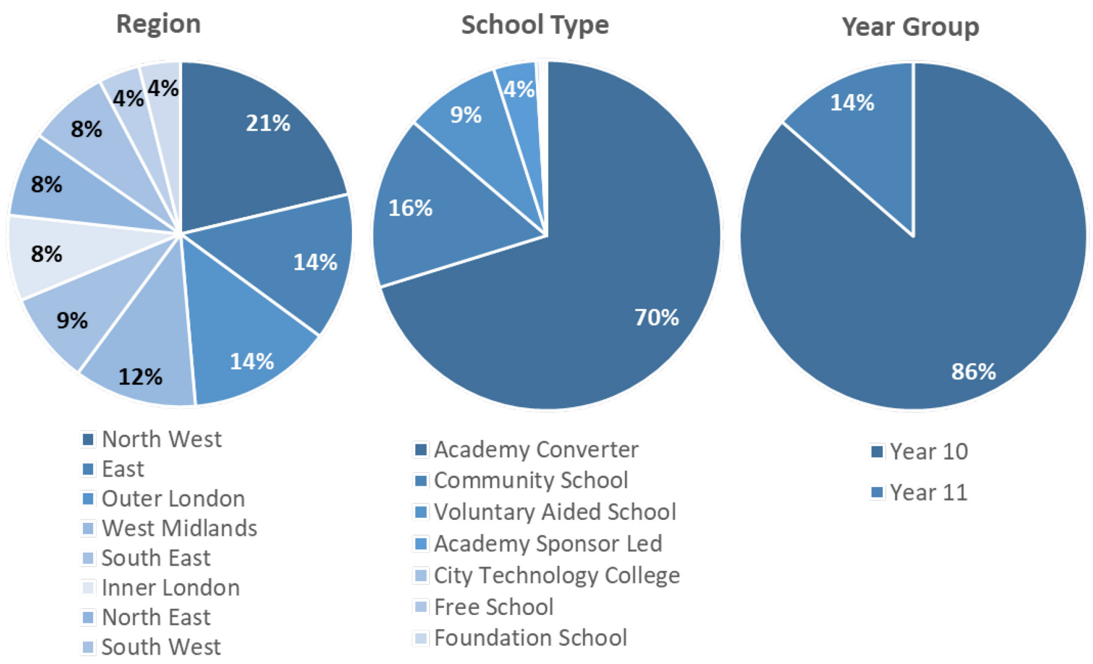

[11] Based on pupils at the end of KS4 in 2019, attending state funded schools https://www.gov.uk/government/statistics/key-stage-4-performance-2019-revised

### 6.1.2. School characteristics

Figure 2 shows the school characteristics of the 1,625 high-achieving girls included in the analysis of primary outcomes. It shows:

- There was a good regional distribution of participating schools, with the North West, East and Outer London the most represented.
- 70% of students attended Academy Converter schools, 16% Community schools, 9% Voluntary aided schools and 4% Academy sponsored schools.
- 86% of students attended Year 10, with only 14% attending year 11.

**Figure 2** Characteristics of schools sampled




### 6.1.3. A Level Choices

Figure 3 details the stated A Level choices of high-achieving girls when first surveyed prior to the first exercise. It shows:

- 72% of high-achieving girls intended to take at least one STEM A Level and 44% intended to take at least two.
- 40% intended to enter an A Level in Maths, 15% in Physics and 7% in Computer Science.

**Figure 3** The stated intention of high-achieving girls to study STEM A Levels before the intervention

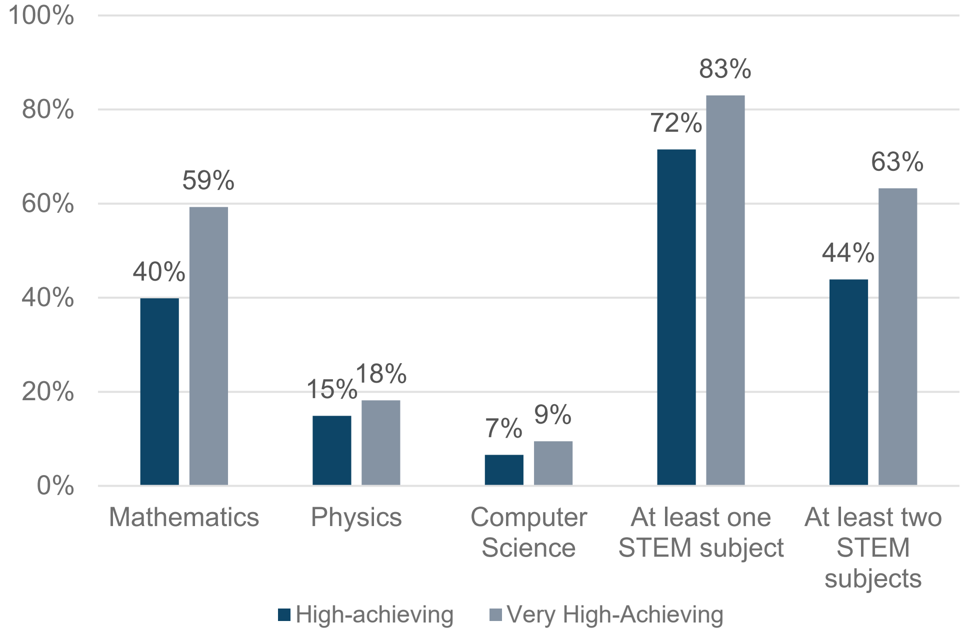
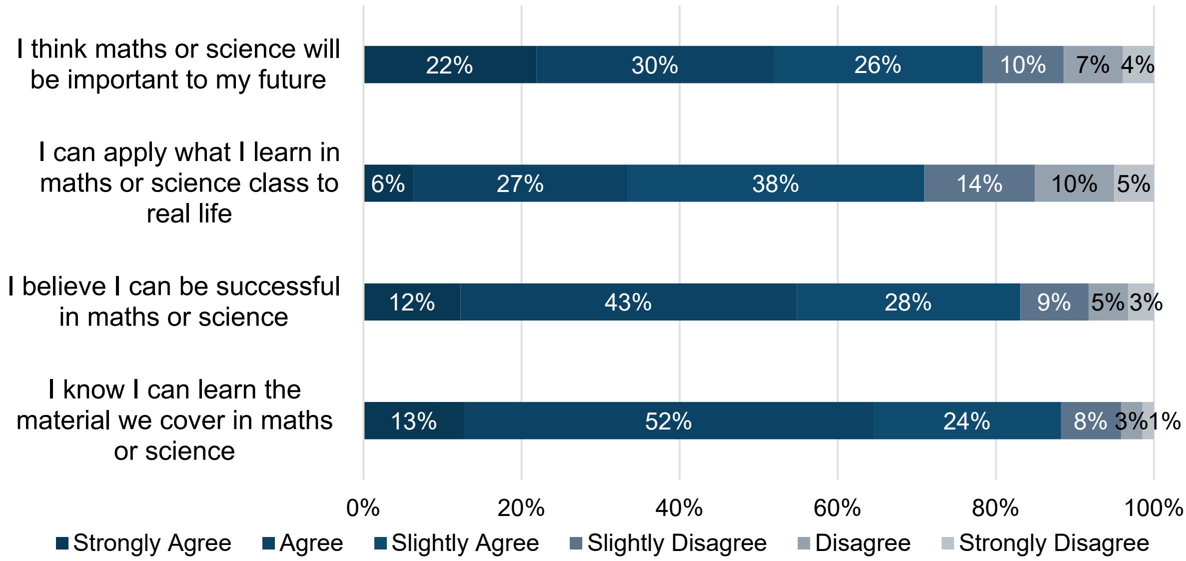



Figure 4 shows the responses of high-achieving girls to the attitudinal questions, when surveyed prior to the first exercise. It shows:

- 52% of girls agreed or strongly agreed that maths or science would be important to their future.
- 33% of girls agreed or strongly agreed that they could apply what they learned in maths or science class to real life.
- 55% of girls agreed or strongly agreed they could be successful in maths or science.
- 65% of girls agreed or strongly agreed they could learn the material covered in maths or science.

**Figure 4** Response to attitudinal survey questions before the intervention




The responses of high-achieving girls' to the parental-focused questions before the start of the trial were:

- 47% of girls reported at least one conversation with parents about A Level choices in the month before the interventions were run.
- 39% of girls reported at least one conversation with parents about the importance of maths and science in the month before the interventions were run.

## 6.2. Summary of outcome measures

**Summary of the outcomes of the intervention**

After treatment, there were the following significant changes for high-achieving girls:

- An increase in the stated intention to study at least two STEM subjects (2 ppt, $p \leq 0.05$)
- A increase in agreement with the statement 'I can apply what I learn in maths or science class to real life' (a 0.17 point increase in the 1 to 6 agreement scale, $p \leq 0.001$)
- A decrease in agreement with the statement 'I know I can learn the material we cover in maths or science' (a 0.06 point decrease in the 1 to 6 agreement scale, $p \leq 0.01$)
- A decrease in agreement with the statement 'I believe I can be successful in maths or science' (a 0.05 point decrease in the 1 to 6 agreement scale, $p \leq 0.05$)
- A decrease in discussion of the importance of maths and science with parents/guardians (5 ppt, $p \leq 0.001$)

For those who received the parent-focused intervention as well, there were the following significant changes:

- A greater increase in the stated intention to study at least two STEM subjects (4 ppt, $p \leq 0.05$)
- A more positive change in discussion of A Level choices with parents/guardians (7 ppt, $p \leq 0.01$)

## 6.3. Primary outcome measures

The primary outcomes measured were based on girls' stated intentions to study STEM A Level subjects and were based on survey data collected at the beginning and end of the trial.

### 6.3.1. Overall treatment effect

Table 4 shows that there was a statistically significant increase in high-achieving girls' intention to study two or more STEM subjects at A Level after treatment.

The positive coefficient of 0.02 is equivalent to a 2ppt increase in the likelihood of a girl taking two or more STEM A Levels after the treatment compared to beforehand: the proportion of girls indicating that they would choose two or more STEM A Levels increased by about 5% (from 44% to 46%).

As shown in Table 4, no significant changes were found in intention to study the individual STEM subjects (maths, physics, computer science or at least one STEM A level). It is possible that the intervention increased the probability of studying an additional STEM subject, on top of a STEM subject already selected. If the additional STEM subject is often different among girls (for some it is Maths, for some Physics, etc), then we may not be powered to detect the effect on each of these individual subjects, while we detect an 'aggregate' effect across STEM subjects'.

**Annex Table 1** shows the same analysis for the subset of 253 ‘very high-achieving’ girls (those with a predicted grade 8 in all maths and science GCSE subjects). No significant changes were found for this smaller group.

**Table 4** Overall treatment effect on intentions to study STEM subjects

| Coefficient Name | Maths (Coef.) | Sig. | Physics (Coef.) | Sig. | Computer Science (Coef.) | Sig. | 1+ STEM subject (Coef.) | Sig. | 2+ STEM subject (Coef.) | Sig. |
|---|---|---|---|---|---|---|---|---|---|---|
| **After treatment** | 0.01 | | 0.00 | | 0.01 | | 0.00 | | 0.02 | * |
| | (0.01) | | (0.01) | | (0.00) | | (0.01) | | (0.01) | |
| **Student fixed effects** | yes | | yes | | yes | | yes | | yes | |
| **R2** | 0.87 | | 0.86 | | 0.87 | | 0.87 | | 0.87 | |
| **Mean in pre-treatment** | 0.40 | | 0.15 | | 0.07 | | 0.72 | | 0.44 | |
| ***N=1,625*** | | | | | | | | | | |

*Data collected through the Behavioural Insights Team's bespoke online platform. Sample restricted to the 1,625 high-achieving girls with complete data (those who provided this information both before exercise 1 and then again after exercise 3). Standard errors are reported in parenthesis. * p ≤ 0.05 ** p ≤ 0.01 *** p ≤ 0.001*

## 6.3.2. Comparing different treatments

Table 5 shows that the increase after treatment – in high-achieving girls’ intention to study two or more STEM subjects at A Level – was significantly greater for the schools that received the parent-focused intervention as well (compared to those that received the student-focused intervention alone).

As shown in Table 5, there were no significant changes for the individual STEM subjects.

**Annex Table 2** shows the same analysis for ‘very high-achieving’ girls only. For this smaller subset, there were no significant differences between the groups in the changes after treatment.

It is worth noting that, despite the fact that schools were randomly assigned to the treatment groups, there were some differences in students' stated intentions to study STEM subjects prior to treatment (indicated by the significant coefficients in the 'parent-focused intervention' rows of Table 5 and **Annex Table 2**).

**Table 5** Relative impact of different treatments on intentions to study STEM subjects

| Coefficient Name | Maths (Coef.) | Sig. | Physics (Coef.) | Sig. | Computer Science (Coef.) | Sig. | 1+ STEM subject (Coef.) | Sig. | 2+ STEM subject (Coef.) | Sig. |
|---|---|---|---|---|---|---|---|---|---|---|
| **After treatment** | 0.00 | | 0.00 | | 0.01 | | -0.01 | | 0.00 | |
| | (0.01) | | (0.01) | | (0.01) | | (0.01) | | (0.01) | |
| **Parent-focused intervention** | -0.51 | * | 0.00 | | 0.00 | | -0.01 | | -0.52 | * |
| | (0.25) | | (0.19) | | (0.13) | | (0.23) | | (0.25) | |
| **After treatment * Parent-focused intervention** | 0.01 | | -0.01 | | -0.01 | | 0.02 | | 0.04 | * |
| | (0.02) | | (0.01) | | (0.01) | | (0.02) | | (0.02) | |
| **Student fixed effects** | yes | | yes | | yes | | yes | | yes | |
| **R2** | 0.87 | | 0.86 | | 0.87 | | 0.87 | | 0.87 | |
| **Mean in pre-treatment** | 0.40 | | 0.15 | | 0.07 | | 0.72 | | 0.44 | |
| ***N=1,625*** | | | | | | | | | | |

*Data collected through the Behavioural Insights Team's bespoke online platform. Sample restricted to the 1,625 high-achieving girls with complete data (those who provided this information both before exercise 1 and then again after exercise 3). Standard errors are reported in parenthesis. * p ≤ 0.05 ** p ≤ 0.01 *** p ≤ 0.001*

## 6.4 Secondary outcome measures

Our focus now turns to analysing the secondary outcome measures. Students were asked six questions both before and after the intervention to identify changes to the following:

- Expectations of success in STEM
- Perceived utility of STEM
- Discussion with parents about A Level choices
- Discussion with parents about the value of STEM subjects

The responses to these questions have been used to explore the overall treatment effect and the relative treatment effect of each intervention.

### 6.4.1. Overall treatment effect

The outcomes of table 6 and 7 are based on the extent to which students agreed with statements about STEM, ranging from 1 (strongly disagree) to 6 (strongly agree).

Table 6 shows that, after treatment, there were the following changes for high-achieving girls:

- An increase in agreement with the statement 'I can apply what I learn in maths or science class to real life' (a 0.17 point increase in the 1 to 6 agreement scale, from 3.90 to 4.07)
- No significant change in agreement with 'I think maths or science will be important to my future'.
- A decrease in agreement with the statement 'I know I can learn the material we cover in maths or science' (a 0.06 point decrease in the 1 to 6 agreement scale, from 4.66 to 4.60)
- A decrease in agreement with the statement 'I believe I can be successful in maths or science' (a 0.05 point decrease in the 1 to 6 agreement scale, from 4.39 to 4.34)

The mean in pre-treatment figures show the average response in the first survey. For example, a value of 4.66 for 'I know I can learn the material we cover in maths or science' indicates agreement levels sat between 'Slightly Agree' (a value of 4) and 'Agree' a value of 5. An 'After Treatment' coefficient value of -0.06  indicates that the average response changed from 4.66 to 4.60.

**Table 6** Overall treatment effect on expectations of success and the perceived utility of STEM subjects

| Coefficient Name | I know I can learn the material we cover in maths or science (Coef.) | Sig. | I believe I can be successful in maths or science (Coef.) | Sig. | I can apply what I learn in maths or science class to real life (Coef.) | Sig. | I think maths or science will be important to my future (Coef.) | Sig. |
|---|---|---|---|---|---|---|---|---|
| **After treatment** | -0.06 | ** | -0.05 | * | 0.17 | *** | 0.02 | |
| | (0.02) | | (0.02) | | (0.02) | | (0.02) | |
| **Student fixed effects** | yes | | yes | | yes | | yes | |
| **R2** | 0.75 | | 0.80 | | 0.79 | | 0.83 | |
| **Mean in pre-treatment** | 4.66 | | 4.39 | | 3.90 | | 4.38 | |
| ***N*** | *2,029* | | *2,007* | | *1,993* | | *2,016* | |

*Data collected through the Behavioural Insights Team's bespoke online platform. Sample restricted to the high-achieving girls with complete data (those who responded to the survey questions before exercise 1 and then again after exercise 3). Standard errors are reported in parenthesis. * p ≤ 0.05 ** p ≤ 0.01 *** p ≤ 0.001*

Table 7 shows that after treatment there was a significant decrease (5 ppt) in reported discussion with parents/guardians about the importance of maths or science in the last month: the proportion of girls reporting having talked to a parent/guardian on this subject at least once in the last month decreased by about 7% (from 75% to 70%)

There was no significant change in reported discussion with parents/guardians about A Level choices in the last month.

**Table 7** Overall treatment effect on self-reported discussions with parents/guardians

| Coefficient Name | I have had at least one conversation with a parent or guardian about my A level choices in the last month (Coef.) | Sig. | I have talked to a parent or guardian at least once about the importance of maths or science in the last month (Coef.) | Sig. |
|---|---|---|---|---|
| **After treatment** | -0.01 | | -0.05 | *** |
| | (0.01) | | (0.01) | |
| **Student fixed effects** | yes | | yes | |
| **R2** | 0.77 | | 0.75 | |
| **Mean in pre-treatment** | 0.56 | | 0.39 | |
| ***N*** | *2,014* | | *2,018* | |

*Data collected through the Behavioural Insights Team's bespoke online platform. Sample restricted to the high-achieving girls with complete data (those who responded to the survey questions before exercise 1 and then again after exercise 3). Standard errors are reported in parenthesis. * p ≤ 0.05 ** p ≤ 0.01 *** p ≤ 0.001.* ***Annex Tables 3 and 4*** *show the same analyses for 'very high-achieving' girls only. The only significant change after treatment was an increase in agreement with the statement 'I can apply what I learn in maths or science class to real life' (a 0.19 point increase in the 1 to 6 agreement scale, p ≤ 0.01).*

### 6.4.2. Comparing different treatments

Table 8 shows that there was a more positive change in high-achieving girls' reported discussions with parents/guardians about A Level choices for schools that received the parent-focused intervention as well (as compared to the schools that received the student-focused intervention alone).

There were no other significant differences between the groups of schools in the changes after treatment in these secondary outcomes, as can be seen in table 9.

**Annex Tables 5 and 6** show the same analyses for 'very high-achieving' girls only. For this smaller subset, no significant differences were found between the groups of schools in the changes after treatment in these secondary outcome measures.

**Table 8** Relative impact of different treatments on self-reported discussions with parents/guardians

| Coefficient Name | I have had at least one conversation with a parent or guardian about my A level choices in the last month (Coef.) | Sig. | I have talked to a parent or guardian at least once about the importance of maths or science in the last month (Coef.) | Sig. |
|---|---|---|---|---|
| **After treatment** | -0.05 | ** | -0.05 | ** |
| | (0.02) | | (0.02) | |
| **Parent-focused intervention** | 0.47 | | -0.50 | |
| | (0.34) | | (0.34) | |
| **After treatment * Parent-focused intervention** | 0.07 | ** | 0.00 | |
| | (0.02) | | (0.02) | |
| **Student fixed effects** | yes | | yes | |
| **R2** | 0.77 | | 0.75 | |
| **Mean in pre-treatment** | 0.56 | | 0.39 | |
| ***N*** | *2,014* | | *2,018* | |

*Data collected through the Behavioural Insights Team's bespoke online platform. Sample restricted to the high-achieving girls with complete data (those who responded to the survey questions before exercise 1 and then again after exercise 3). Standard errors are reported in parenthesis. * p ≤ 0.05 ** p ≤ 0.01 *** p ≤ 0.001*

**Table 9** Relative impact of different treatments on expectations of success and the perceived utility of STEM subjects

| Coefficient Name | I know I can learn the material we cover in maths or science (Coef.) | Sig. | I believe I can be successful in maths or science (Coef.) | Sig. | I can apply what I learn in maths or science class to real life (Coef.) | Sig. | I think maths or science will be important to my future (Coef.) | Sig. |
|---|---|---|---|---|---|---|---|---|
| **After treatment** | -0.07 | * | -0.04 | | 0.20 | *** | 0.01 | |
| | (0.03) | | (0.03) | | (0.04) | | (0.04) | |
| **Parent-focused intervention** | 0.49 | | 0.51 | | 0.02 | | -0.01 | |
| | (0.69) | | (0.71) | | (0.78) | | (0.76) | |
| **After treatment * Parent-focused intervention** | 0.01 | | -0.01 | | -0.05 | | 0.02 | |
| | (0.04) | | (0.04) | | (0.05) | | (0.05) | |
| **Student fixed effects** | yes | | yes | | yes | | yes | |
| **R2** | 0.75 | | 0.80 | | 0.79 | | 0.83 | |
| **Mean in pre-treatment** | 4.66 | | 4.39 | | 3.90 | | 4.38 | |
| ***N*** | *2,029* | | *2,007* | | *1,993* | | *2,016* | |

*Data collected through the Behavioural Insights Team's bespoke online platform. Sample restricted to the high-achieving girls with complete data (those who responded to the survey questions before exercise 1 and then again after exercise 3). Standard errors are reported in parenthesis. * $p \le 0.05$ ** $p \le 0.01$ *** $p \le 0.001$*

## 6.4.3. Differential effect on girls when compared to boys for the primary outcomes

Table 10 shows that the change in stated intentions to study STEM subjects after treatment was not significantly different in high-achieving girls and high-achieving boys.

The positive 'Boys' coefficients seen for physics and computing highlight that boys were twice as likely to express an intention to take both physics and computer science prior to any intervention, once student fixed effects were controlled for.

These results should be treated with caution, as it is unclear whether schools have implemented these interventions in the same way for both boys and girls. A school's decision as to which students could engage with the interventions may introduce a selection bias into these results.

**Table 10** Relative treatment effect for boys and girls on subject intentions

| Coefficient Name | Maths (Coef.) | Sig. | Physics (Coef.) | Sig. | Computer Science (Coef.) | Sig. | 1+ STEM subject (Coef.) | Sig | 2+ STEM subject (Coef.) | Sig |
|---|---|---|---|---|---|---|---|---|---|---|
| After treatment | -0.02 | | 0.00 | | -0.01 | | 0.01 | | 0.01 | |
| | (0.01) | | (0.01) | | (0.01) | | (0.01) | | (0.01) | |
| Boys | 0.01 | | 1.00 | *** | 1.01 | *** | 0.00 | | 0.01 | |
| | (0.28) | | (0.23) | | (0.18) | | (0.23) | | (0.26) | |
| After treatment - Boys | 0.02 | | 0.00 | | 0.02 | | -0.01 | | 0.01 | |
| | (0.02) | | (0.01) | | (0.01) | | (0.01) | | (0.01) | |
| Student fixed effects | yes | | yes | | yes | | yes | | yes | |
| R2 | 0.85 | | 0.86 | | 0.87 | | 0.86 | | 0.87 | |
| Mean in pre-treatment | 0.47 | | 0.24 | | 0.15 | | 0.76 | | 0.52 | |
| *N=2,640* | | | | | | | | | | |

*Data collected through a bespoke online platform. Sample restricted to the 2,640 high-achieving students with complete data (those who provided this information both before exercise 1 and then again after exercise 3). Standard errors are reported in parenthesis. * p ≤ 0.05 ** p ≤ 0.01 *** p ≤ 0.001*

### 6.4.4. Comparison of the treated year group with the previous, untreated, year group

This analysis compares, within the same schools, the formal STEM A Level subject preferences amongst students in the 'treated' year group with the STEM A Level uptake amongst students in the previous year group (none of whom received the interventions). Table 11 shows that there were no significant differences in the final STEM A Level subject choices (as submitted by schools) between the treated cohort and the preceding, untreated, cohort.

Only schools with sixth forms that supplied a complete set of data for both cohorts were included in this analysis; this reduced the sample to only 30 schools.

The lack of statistically significant findings may be due in part to the low sample size. There are also likely to be differences between the cohorts, as listed in the assumptions section, which are not controlled for in the analysis; these results should therefore be treated with some caution.

**Table 11** Cross-cohort analysis, overall treatment effect

| Coefficient Name | % girls choosing Maths (Coef.) | Sig. | % girls choosing Physics (Coef.) | Sig. | % girls choosing Computing (Coef.) | Sig. | % girls choosing one or more STEM A Level (Coef.) | Sig. | % girls choosing two or more STEM A Level (Coef.) | Sig. |
|---|---|---|---|---|---|---|---|---|---|---|
| **Treated cohort** | 0.02 | | 0.01 | | 0.01 | | -0.04 | | 0.00 | |
| | (0.03) | | (0.01) | | (0.01) | | (0.04) | | (0.02) | |
| **Cohort Year Group 11 (base line year 10)** | -0.09 | | 0.02 | | 0.02 | | 0.11 | | 0.08 | |
| | (0.12) | | (0.04) | | (0.02) | | (0.14) | | (0.07) | |
| **Percentage of girls in cohort** | -0.02 | | 0.08 | | -0.02 | | -0.20 | | 0.05 | |
| | (0.44) | | (0.14) | | (0.08) | | (0.51) | | (0.27) | |
| **School Type fixed effects** | yes | | yes | | yes | | yes | | yes | |
| **School FE** | Yes | | Yes | | Yes | | Yes | | Yes | |
| **R2** | 0.57 | | 0.70 | | 0.74 | | 0.76 | | 0.80 | |
| **Mean in pre-treatment** | 0.23 | | 0.06 | | 0.02 | | 0.38 | | 0.21 | |
| ***N*** | *30* | | *30* | | *30* | | *30* | | *30* | |

*Data submitted by schools. Sample restricted to the 30 schools with sixth forms that provided data for both the treated cohort and the preceding cohort. Standard errors are reported in parenthesis. * p ≤ 0.05 ** p ≤ 0.01 *** p ≤ 0.001*

Table 12 shows that no significant differences in the cross-cohort analysis were found for schools that received the parent-focused intervention in addition to the student-focused one.

**Table 12** Cross-cohort analysis, comparing different treatments

| Coefficient Name | % girls choosing Maths (Coef.) | Sig | % girls choosing Physics (Coef.) | Sig | % girls choosing Computing (Coef.) | Sig | % girls choosing one or more STEM A Level (Coef.) | Sig | % girls choosing two or more STEM A Level (Coef.) | Sig |
|---|---|---|---|---|---|---|---|---|---|---|
| **Treated cohort** | -0.07 | | -0.02 | | -0.01 | | -0.01 | | 0.00 | |
| | (0.04) | | (0.01) | | (0.01) | | (0.05) | | (0.03) | |
| **Parent-focused intervention** | 0.02 | | -0.01 | | 0.01 | | 0.41 | ** | 0.20 | * |
| | (0.11) | | (0.04) | | (0.02) | | (0.14) | | (0.08) | |
| **Treated cohort * parent-focused intervention** | 0.12 | | 0.02 | | 0.01 | | 0.09 | | 0.00 | |
| | (0.06) | | (0.02) | | (0.01) | | (0.07) | | (0.04) | |
| **Cohort Year Group (base line year 10)** | -0.17 | | 0.02 | | 0.00 | | -0.34 | | -0.12 | |
| | (0.16) | | (0.06) | | (0.03) | | (0.19) | | (0.11) | |
| **Percentage of girls in cohort** | 0.02 | | 0.09 | | -0.01 | | -0.16 | | 0.06 | |
| | (0.42) | | (0.14) | | (0.08) | | (0.5) | | (0.28) | |
| **School Type fixed effects** | yes | | yes | | yes | | yes | | yes | |
| **R2** | 0.63 | | 0.71 | | 0.75 | | 0.78 | | 0.80 | |
| **Mean in pre-treatment** | 0.23 | | 0.06 | | 0.02 | | 0.38 | | 0.21 | |
| ***N*** | *30* | | *30* | | *30* | | *30* | | *30* | |

*Data submitted by schools. Sample restricted to the 30 schools with sixth forms that provided data for both the treated cohort and the preceding cohort. Standard errors are reported in parenthesis. * p ≤ 0.05 ** p ≤ 0.01 *** p ≤ 0.001*

### 6.4.5. Correlation between the intention to study STEM subjects and actual A Level choices

Students' formally-submitted A Level choices, provided by schools, were compared to students' stated intentions when surveyed at the end of the trial.

Table 13 shows that intention and actual choice are strongly correlated. A student stating that they intend to choose a STEM subject is almost five times more likely to enrol in this subject, compared to a student who did not intend to do so. Of the high-achieving girls who stated an intention to take at least one STEM A level 73% went on to take one.

Overall, not everyone who expressed intention to study a STEM subject selected a STEM subject as a final choice. This was also the case for non-STEM subjects.

**Table 13** Correlation between stated intention to study STEM subjects and actual A Level subject choices

| Coefficient Name | Maths (Coef.) | Sig. | Physics (Coef.) | Sig. | Computer Science (Coef.) | Sig. | 1+ STEM subject (Coef.) | Sig. | 2+ STEM subject (Coef.) | Sig. |
|---|---|---|---|---|---|---|---|---|---|---|
| **Intention to study subject at A-level** | 0.50 | *** | 0.39 | *** | 0.43 | *** | 0.53 | *** | 0.52 | *** |
| | (0.02) | | (0.02) | | (0.02) | | (0.03) | | (0.02) | |
| **Ever FSM** | -0.05 | | -0.01 | | -0.04 | ** | -0.07 | | -0.03 | |
| | (0.04) | | (0.03) | | (0.01) | | (0.04) | | (0.03) | |
| **Cohort Year Group 11 (base line year 10)** | 0.01 | | 0.01 | | 0.00 | | 0.11 | ** | 0.05 | |
| | (0.03) | | (0.02) | | (0.01) | | (0.04) | | (0.03) | |
| **Predicted Achievement** | | | | | | | | | | |
| *High achieving* | 0.05 | | -0.04 | | -0.01 | | 0.07 | | -0.03 | |
| | 0.05 | | 0.03 | | 0.02 | | 0.05 | | 0.04 | |
| *Very high achieving* | 0.13 | * | -0.01 | | 0.00 | | 0.15 | ** | 0.10 | * |
| | 0.05 | | 0.04 | | 0.02 | | 0.06 | | 0.05 | |
| **Ethnicity** | | | | | | | | | | |
| *Irish* | -0.20 | | 0.04 | | 0.00 | | -0.31 | * | -0.10 | |
| | (0.12) | | (0.08) | | (0.05) | | (0.13) | | (0.12) | |
| *Any other White background* | 0.06 | | 0.07 | * | 0.04 | * | 0.07 | | 0.07 | |
| | (0.05) | | (0.03) | | (0.02) | | (0.05) | | (0.05) | |
| *White and Black Caribbean* | 0.07 | | 0.16 | * | -0.05 | | 0.04 | | 0.08 | |
| | (0.1) | | (0.07) | | (0.04) | | (0.1) | | (0.09) | |
| *White and Black African* | -0.16 | | -0.05 | | -0.03 | | -0.02 | | -0.22 | * |
| | (0.11) | | (0.07) | | (0.04) | | (0.12) | | (0.1) | |
| *White and Asian* | 0.07 | | -0.01 | | 0.03 | | 0.09 | | 0.06 | |
| | (0.09) | | (0.06) | | (0.03) | | (0.09) | | (0.08) | |
| *Any other Mixed / Multiple ethnic background* | 0.08 | | 0.03 | | -0.02 | | 0.11 | | 0.13 | |
| | (0.09) | | (0.06) | | (0.04) | | (0.1) | | (0.09) | |
| *Indian* | 0.11 | * | 0.05 | | 0.00 | | 0.24 | *** | 0.20 | *** |
| | (0.04) | | (0.03) | | (0.02) | | (0.05) | | (0.04) | |
| *Pakistani* | 0.03 | | 0.01 | | -0.03 | | 0.21 | ** | 0.25 | *** |
| | (0.06) | | (0.04) | | (0.02) | | (0.06) | | (0.06) | |
| *Bangladeshi* | 0.27 | ** | 0.17 | ** | 0.06 | * | 0.24 | ** | 0.34 | *** |
| | (0.08) | | (0.05) | | (0.03) | | (0.09) | | (0.08) | |
| *Chinese* | 0.10 | | -0.02 | | 0.03 | | 0.28 | * | 0.17 | |
| | (0.1) | | (0.07) | | (0.04) | | (0.11) | | (0.1) | |
| *Any other Asian background* | 0.15 | * | 0.11 | * | 0.09 | *** | 0.16 | * | 0.26 | *** |
| | (0.06) | | (0.04) | | (0.02) | | (0.07) | | (0.06) | |
| *African* | 0.20 | *** | -0.02 | | 0.00 | | 0.14 | * | 0.21 | *** |
| | (0.05) | | (0.04) | | (0.02) | | (0.06) | | (0.05) | |
| *Caribbean* | 0.02 | | -0.10 | | 0.00 | | -0.04 | | -0.03 | |
| | (0.17) | | (0.12) | | (0.07) | | (0.18) | | (0.16) | |
| *Any other Black / African / Caribbean background* | 0.21 | | 0.17 | | -0.05 | | 0.10 | | -0.02 | |
| | (0.14) | | (0.09) | | (0.05) | | (0.15) | | (0.13) | |
| *Any other ethnic group* | -0.17 | | 0.03 | | -0.03 | | -0.12 | | -0.07 | |
| | (0.1) | | (0.07) | | (0.04) | | (0.11) | | (0.09) | |
| **R2** | 0.34 | | 0.24 | | 0.39 | | 0.33 | | 0.42 | |
| ***N*** | *1,318* | | *1,318* | | *1,318* | | *1,318* | | *1,318* | |

*Data collected from a bespoke online platform and submitted by schools. Sample restricted to the 639 high-achieving girls for whom there was both survey data and actual subject choices available. Standard errors are reported in parenthesis. * p ≤ 0.05 ** p ≤ 0.01 *** p ≤ 0.001*

# 7. Discussion

## 7.1. Intervention impact

The aim of the interventions in this study was to increase high-achieving girls' uptake of STEM A Levels. After the interventions, high-achieving girls were significantly more likely to state the intention to study two or more STEM A Levels (a 2 percentage point increase, $p \leq 0.05$). This positive change was significantly greater for high-achieving girls in schools that received the parent-focused intervention in addition to the student-focused intervention (by 4 percentage points, $p \leq 0.05$). Uptake of two or more STEM A Levels was an outcome of particular interest for this research because this is a pre-requisite for the majority of university STEM pathways in which girls are currently under-represented.

The principle mechanism by which the interventions sought to increase girls' uptake of STEM A Levels was by improving perceptions of STEM's utility – this was the target of the parent-focused intervention, as well as two of the three student-focused intervention exercises. After the interventions, high-achieving girls expressed significantly greater agreement with the statement "I can apply what I learn in maths or science class to real life" – a measure of the perceived utility of STEM (a 0.17 point increase in the 1 to 6 agreement scale, $p \leq 0.001$).

One of the two student-focused intervention exercises sought to increase students' expectations of success in STEM. However, after the interventions, high-achieving girls expressed significantly less agreement with the statements "I know I can learn the material we cover in maths or science" (a 0.06 point decrease in the 1 to 6 agreement scale, $p \leq 0.01$) and "I believe I can be successful in maths or science" (a 0.05 point decrease in the 1 to 6 agreement scale, $p \leq 0.05$). Given the nature of the research design, the reason for these small changes is not clear. While it is conceivable that the intervention had an unintended backfire effect on expectations of success in STEM, an alternative explanation is that students tend to become less confident in their ability in STEM over time, as they get closer to their GCSE exams. Indeed, it is even possible that the intervention counteracted a natural decline that would, otherwise, have been larger.

After the interventions, as compared to before the interventions, high-achieving girls were significantly less likely to report having discussed the importance of maths or science with their parents in the last month (a 5 percentage point decrease, $p \leq 0.001$). One possible explanation for this finding is that the month prior to the interventions contained a school holiday, affording more opportunities for conversations with parents, whereas the month preceding the end of the interventions did not. However, high-achieving girls in schools that received the parent-focused intervention in addition to the student-focused intervention showed a relative increase in self-reported discussions with their parents about A Level choices (by 7 percentage points, $p \leq 0.01$).

**It is important to note that no causal inferences can be made between the activities run for students and parents and the changes recorded in primary and secondary outcome measures. There are many external factors that are likely to influence students' perceptions of STEM subjects and indeed their final A Level choices and without a viable control group for comparison, it is difficult to separate the impacts of these external influences from the trial itself.**

There was a strong relationship between the intentions of girls to study STEM subjects with their final A Level choices. While this is reassuring, not all stated intentions to study STEM A Levels translated into formally-submitted A Level preferences (as was also the case for non-STEM A Levels). This may be explained by a natural intention-action gap, meaning that there is a difference between what people say they plan to do and what they actually do. It is also possible that the design of the surveys had an impact on this outcome. In the surveys, students could select more subjects than the standard number of A Levels for which students generally enrol. As a result, some students may have included more subjects in their stated intentions than it was actually feasible for them to choose.

We need to be similarly cautious when interpreting the comparisons made between the two treatment groups. The analysis was severely underpowered, and it cannot be excluded that there were no other confounding factors affecting the observed changes in the survey responses of each group. Nevertheless, students benefiting from parental-focused activities did show an increased likelihood of discussing A Level choices with their parent or guardian after the trial, and this is something which clearly warrants further exploration.

This research sought to have an immediate impact on girls' A Level choices. However, the longer-term effects of societal norms or general expectations about the challenges of the subject matter itself may require that interventions are targeted much earlier, particularly for girls.

## 7.2. Limitations

- School dropout

Despite having initially agreed to take part in the intervention, some schools dropped out and decided not to implement the intervention (as is typical in trials). This had two potential consequences: 1) schools may have disproportionately dropped out from one of the two treatments. If attrition was non-random across the two groups, the comparison of student only and student+parent intervention may suffer from selection bias. For analyses that do not test the differential impact of the two treatments, this does not cause a problem *per se;* 2) schools who took part in the intervention may have been a selected sample with particular characteristics for which the treatments may be more or less beneficial with respect to the general population of schools. This may affect the generalisability of the results.

A simple comparison of the characteristics of students in the sample (as reported in the Descriptive Statistics section, Figure 1) to national figures shows that the treated sample is not nationally representative. For instance, the FSM rate in secondary schools in England[12] is 14.1%, while the rate in the sample is 12%. Similarly, schools in the North West are overrepresented in the sample at 21%, while 14% of state-funded secondary schools are in the North West as of 2019[13].

The schools were free to administer the interventions to whomever they chose within the target year group. They were asked to administer them to every student or to high-attaining students only, as they saw fit. This has three potential consequences.

First, if schools choose to deliver the intervention only to students who may benefit the most from the intervention, the effect of treatment may have been overestimated.

Second, student selection implies that the cross-cohort analysis estimates are to be interpreted as intention to treat, rather than average treatment effect.

Third, it is not certain that the girls and boys who took part in the activities were matched, or representative of the schools, in terms of achievement level. This complicates the interpretation of gender difference analysis, as attainment is known to be a moderator of the impact of interventions of this kind, and to operate differently for girls and boys[14].

- Student-level attrition

Dropout of students from later stages of the intervention raises concerns for the generalisability of the evaluation. It is possible that students who dropped out were the ones for which the treatment would have had the smallest/greatest effect.

The reduction in student numbers also impacts the power of the statistical models produced, reducing the minimum change in survey responses it was possible to detect.

- The lack of syncing between the parent and student interventions

The timing of the administration of the student intervention activities was at the schools' discretion. For some schools, the initial communication of the parent intervention may have been delivered prior to the first student intervention activity (and, therefore, before the 'pre' measures). Furthermore, some schools may have delivered the third student intervention activity (which included the post-survey with the final outcomes measures)

[12] DfE, Percentage of pupils eligible for and claiming free school meals (FSM) in England, 2011-2019 (link)
[13] DfE, Schools, Pupils and their Characteristics: January 2019 (link)
[14] Rozek CS, Hyde JS, Svoboda RC, Hulleman CS, Harackiewicz JM (2015) Gender differences in the effects of a utility-value intervention to help parents motivate adolescents in mathematics and science. J Educ Psychol 107(1):195–206.

before all parental correspondence has been completed. This implies that the true effect of the parent-focused intervention may be underestimated.

- Technical difficulties

The intervention implementation was not entirely smooth during the early stages. For example, there were some complications with the parent website, and the video testimonials from students (about the ways in which STEM has been useful in their lives) may have been inaccessible for at least part of the intervention period. This implies that the treatment effects are considered as intention to treat.

- Prompts within the student-focused intervention to talk with parents

Prompts to speak with a parent/carer about post-16 choices and the value of STEM were written into the student-focused interventions when the research design was an individual-level RCT with the following treatment conditions: control; parent-focused intervention only; parent-focused intervention + student-focused intervention. However, when the research design was changed (to be a pre-post study design with all schools receiving the student-focused intervention and half of schools additionally receiving the parent-focused intervention) these prompts were not removed from the student-focused intervention. These prompts may well have influenced parent-child conversations about the value of STEM in the student-focused intervention only condition, making it relatively harder to see an added effect of the parent-focused intervention (when the comparison was already underpowered due to the change in design).

# 8. Recommendations

## 8.1. Future research

Without a robust control group, it is difficult to be certain of what would have happened in the absence of the interventions. Therefore, the effectiveness of the interventions remains uncertain. Future research incorporating a valid control group, ideally from a randomised control trial, would be very valuable. Given the department's preference for randomising at school level to ensure students within a school are not unfairly disadvantaged by different provision, a larger sample of schools would be required. This future research could have the added benefit of using actual A Level subjects taken as the outcome measure, which was outside the scope of the timeline of the current project.

The effects of the novel coronavirus (COVID-19) impacts the recommendations for further research in the short-term. In light of the disruption of teaching, examination and assessment in 2020[15] and the Ofqual consultation to consider a range of possible measures to free up teaching time[16], education providers will need to prioritise covering core curriculum content and supporting young people to progress to further study. Therefore, further research employing the student-focused intervention exercises in school hours is unlikely to be feasible in the coming months.

This may however open up opportunities to carry out research on the impact that COVID-19-related changes are having on STEM uptake (compared to other subjects); provided the regional effects of any changes are uniform across the entire student cohort in England, sampling conditions would be ideal. Additionally, the prevalence of online learning and accessing resources remotely throughout the pandemic may provide additional benefits to delivering an at-home online intervention, as young people would be more comfortable and familiar with learning in this way. It may also be a way to reduce the administrative burden on participating schools. Further research using the parent-focused intervention could also be feasible, as this places no burden on teaching time.

The present research sought to have an immediate impact on girls' A Level choices. However, it would be remiss to omit that there is a wealth of evidence (McGuire et al., 2019; Sullivan, 2019; Van Den Hurk et al., 2019) for starting STEM interventions much earlier. It may be too late to generate a long-term impact on female students' perception of STEM just before they are about to choose their A Level subjects. The perceived value of STEM and students' expectations of personal success in these subjects must be consistently built upon, and success and achievement in STEM subjects across both genders needs to be normalised from an early age. The recommendation would be to

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15 DfE Guidance Coronavirus (COVID-19): cancellation of GCSEs, AS and A levels in 2020 (link)
16 Ofqual launches consultation on 2021 exams and assessments (link)

start interventions earlier, in addition to a timely nudge just before students make their further education decisions.

### 8.1.1. The influence of other research on future plans

- ASPIRES

While this research was ongoing, the research team for ASPIRES released the report for the second wave of the research – ASPIRES 2. The findings of the ASPIRES 2 research was used to understand some of the outcomes from this research. When planning any future work, it would be useful to draw upon some of theories posited, specifically those examining influences for 'careers education' and 'masculine science' and 'clever science'. It would also be useful to examine capital-related inequalities which the research did not explicitly address.

At the time of publishing, the next phase of the research – ASPIRES 3 – has been initiated and seeks to build on previous research. The ASPIRES team will continue to track the same cohort of young people in order to 'understand the changing influences of the family, school, careers education and social identities and inequalities on young people's science and career aspirations'.

- Science Education Tracker

Similarly, the Wellcome Trust published its findings on young people's views on science education and careers. This was based on a survey of more than 6,400 students in years 7-13 (aged 11-18) in schools and colleges across England. Among other key findings, the survey found that many young people do not see science as relevant to their everyday lives or future plans. Female students in years 10-13 were found to be less likely than male students to rate themselves as good at maths (63% males, 51% females) or physics (46% males, 28% females).

- PISA 2018

PISA 2018 found that while English students outperform counterparts in OECD countries in maths, the gender gap is larger, and the pattern is the opposite to that seen in national tests such as GCSEs. Finland was noted as a notable exception to this trend, with girls outperforming boys. Positive findings indicate that in science, both girls and boys outperformed counterparts in the OECD, however, once again girls in Finland outperformed boys by a large margin. Perhaps it would be useful to understand practices in this country and see whether they can be applied within this context. Interestingly, there will be a focus on science in PISA 2024 with an aim to better understand levels of scientific literacy and how science is applied in a real-life context.

- Public Attitudes to Science (PAS)

The recently published PAS report also gives us a good measure of the UK population's perception of and engagement with science, which is useful when planning future research, particularly around the utility value of STEM. Science was seen as a 'broad and ambiguous topic synonymous with technological advancement'. There was a broad agreement about the importance of science in our lives, particularly in terms of healthcare. This finding may also be an interesting area to explore in terms of whether there is any correlation between perception of healthcare for girls and their higher levels of uptake of biology and chemistry than boys. There was widespread agreement that science plays a fundamental role in society and key to improving it which is also consistent with the ASPIRES 2 finding that persistent, low science aspirations are not due to a lack of interest in science (Archer, 2020).

## 8.2. Recommended adaptations for the present interventions

### 8.2.1. Targeting

Where possible, interventions of this kind should be delivered to a targeted group – those who are expected to be eligible for STEM A Levels. First, this would help to personalise the intervention; personalisation is known to capture attention and promote behaviour change.[17] Second, it would allow the interventions to allude to the student's success in STEM subjects to date, helping to increase expectations of success if they were to continue with these subjects at A Level. Third, it would mean that these interventions, including the correspondence to parents, could represent specific encouragement for the selected students, which is associated with continued participation in STEM subjects,[18] and a gender disparity in encouragement is thought to be at least partly responsible for the gender gap in STEM participation.[19] Finally, it would help ensure that the interventions are relevant and suitable for all students receiving them. However, the way that such interventions are presented and framed is important: if girls feel singled out on the basis of their gender or receive the message that girls are currently underrepresented in STEM fields, this could potentially backfire.

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[17] The Behavioural Insights Team (2014). EAST: Four Simple Ways to Apply Behavioural Insights

[18] Archer, L., & Tomei, A. (2013). What influences participation in science and mathematics. A briefing paper from the Economic and Social Research Council (ESRC) Targeted Initiative on Science and Mathematics Education (TISME)(ESRC, Swindon).

[19] Newall, C., Gonsalkorale, K., Walker, E., Forbes, G. A., Highfield, K., & Sweller, N. (2018). Science education: Adult biases because of the child's gender and gender stereotypicality. Contemporary Educational Psychology, 55, 30-41.
Accenture (2017) Girls in STEM
Ipsos MORI (2019) Omnibus survey of pupils and their parents or carers: wave 5

If interventions are not targeted, the recommendation would be to expand the interventions to pertain to a variety of post-16 STEM routes, rather than STEM A Levels exclusively, and that the student interventions are video based, rather than text based, to increase their accessibility.

It should be noted that interventions delivered at an earlier stage of development would require less targeting, as there would be more time for attainment to improve.

### 8.2.2. Timing

In this project, the interventions were implemented during the spring term. This meant that it was necessary to work with year 10 students in schools in which year 11 students had already been asked to indicate their A Level subject preferences. As mentioned above, future research could seek to intervene earlier in students' development, in conjunction with timely nudges just before students make their decisions. For STEM A Level decisions, such timely nudges would be best delivered in autumn term in year 11. This would have the added benefits of giving schools more time to deliver the student interventions and minimizing burden on schools in the run up to exam time.

### 8.2.3. Additional options

It may be helpful to broaden the communications for the parent intervention to include text messages and/or physical post, as these are likely to be more salient options for some parents.

The parent website in this project focused heavily on boosting parents' perceptions of the utility of STEM for their child. However, it could, in future iterations, be extended in a variety of ways. For example, messages to increase the sense that their child belongs in STEM, and to boost confidence, could be built in.

# Annex A

## School-level randomisation balance checks

**Table 14** Characteristics of students sampled

| Variable | Arm 1 | Arm 2 | P-value of the difference |
|---|---|---|---|
| Share of FSM students | 0.224 | 0.184 | 0.310 |
| Share of students whose ethnicity is white | 0.690 | 0.636 | 0.477 |
| Average expected score in GCSEs Maths | 5.538 | 5.741 | 0.382 |
| Average expected score in GCSEs Maths, girls only | 5.540 | 5.758 | 0.339 |
| Share of girls with imputed expected GCSE | 0.030 | 0.062 | 0.468 |
| Share of girls in the year-group | 0.599 | 0.621 | 0.680 |
| Share of girls in the school | 0.559 | 0.548 | 0.806 |
| Year group size | 169.914 | 168.242 | 0.921 |
| Finishing age | 17.429 | 17.515 | 0.691 |
| School is LA maintained | 0.257 | 0.333 | 0.498 |
| School is single gender | 0.143 | 0.152 | 0.921 |
| School is non-religious | 0.800 | 0.758 | 0.679 |
| School is in London | 0.143 | 0.212 | 0.461 |

[20] The p-value of the differences between the two arms are greater than 0.05 and are therefore not statistically significant at the 95% level.

# Annex B

## Survey measures

1. If you were to take AS and A Levels, and if you had to make your subject choices right now, how sure would you feel of your choices?
(a) Sure
(b) Somewhat sure
(c) Not sure at all

2. If you answered (a) or (b), which subjects would you choose (please select up to five)? [NB the subjects were presented in a random order]

English literature
Spanish
Biology
Chemistry
Geography
History
Physics
Computing/computer science
Further maths
German
Art and design
Business studies
French
Sociology
Psychology
Maths
Other (please specify):
Other (please specify):
Other (please specify):
Other (please specify):
Other (please specify):

Please read the following statements and indicate the extent to which you agree or disagree with each. Remember, please respond openly and honestly; your answers won't be shared with your school.

---

1. I know I can learn the material we cover in maths or science
Strongly disagee
Disagree
Slightly disagree
Slightly agree
Agree
Strongly agree

2. I believe I can be successful in maths or science
Strongly disagee
Disagree
Slightly disagree
Slightly agree
Agree
Strongly agree

3. I can apply what I learn in maths or science class to real life
Strongly disagee
Disagree
Slightly disagree
Slightly agree
Agree
Strongly agree

4. I think maths or science will be important to my future
Strongly disagree
Disagree
Slightly disagree
Slightly agree
Agree
Strongly agree

5. I have had at least one conversation with a parent or guardian about my A Level choices in the last month
Yes
Not sure
No

6. I have talked to a parent or guardian at least once about the importance of maths or science in the last month
Yes
Not sure
No

# Annex C

## Interventions

### Student-focused intervention

#### Overarching intro Text

Over the coming weeks you will have some time in class to work through the following three exercises. These have been designed to help students like yourself reflect on your school life and explore links to your wider goals and future choices. Each exercise will take around 30 minutes.

Many students in schools across the country are also completing these tasks.

It is important that you answer honestly and try your best to complete each exercise in full. Your answers will not be shared with your teachers or school and there are no right or wrong answers. You also do not need to worry about spelling, punctuation or grammar for this exercise; just get your thoughts down.

If you have any questions about the exercises either in or outside class please ask a teacher.

#### Exercise 1 Expectancy

*Designed to counteract girls' tendency to believe that they are not 'smart' enough to do these subjects (despite performing equally well at them)*

**Section 1**

<u>What research and other students say about how to do well in school.</u>

In this exercise, you will get the opportunity to support fellow students to achieve their potential as they approach their GCSEs and decide what to do next. It will start with information from research, followed by quotations from other students, and then you will be invited to contribute your own message for future students.

You will see that many of the examples relate to Maths, Physics, Chemistry, Biology and Computer Science (known as STEM subjects). This is because:

1) These subjects open doors to a wide range of education and career opportunities;

2) People with skills in STEM play an important role in making a positive difference to people's lives and the world we live in, as the world relies more and more on technology;

3) Skills and information learnt in STEM subjects are very relevant to everyday life; they can be used to help improve your health and well-being, your financial situation and your understanding of the world around you.

---

Three lessons for achieving success

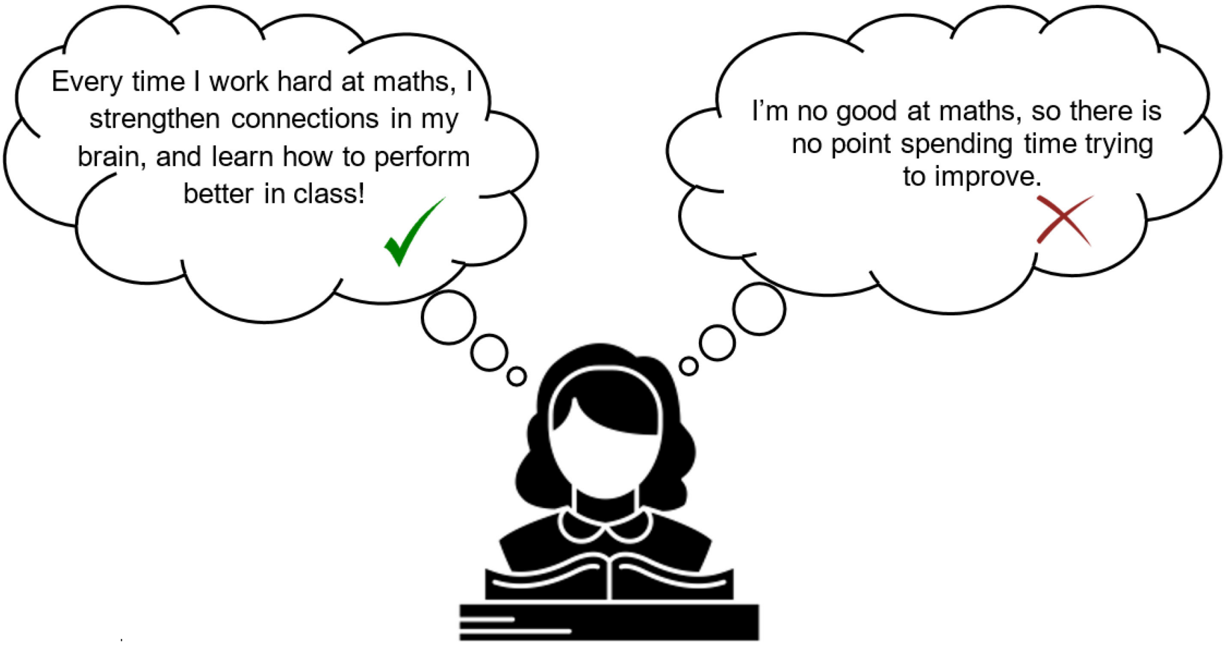
Some people underestimate their ability in maths, science and technology. They think they can't do it when they really can, and this holds them back from fulfilling their potential. By remembering three lessons, people can avoid this happening to them.

1. Effort is the most important factor for success and everybody can improve.

Some people believe you are either naturally good at maths or science or you're not, so effort doesn't make a difference. **This is not the case; there is a lot of evidence to show how much of a difference effort can make.**

Research shows that putting in effort to learn something builds and strengthens connections in the brain, making us better at the task the next time we try.

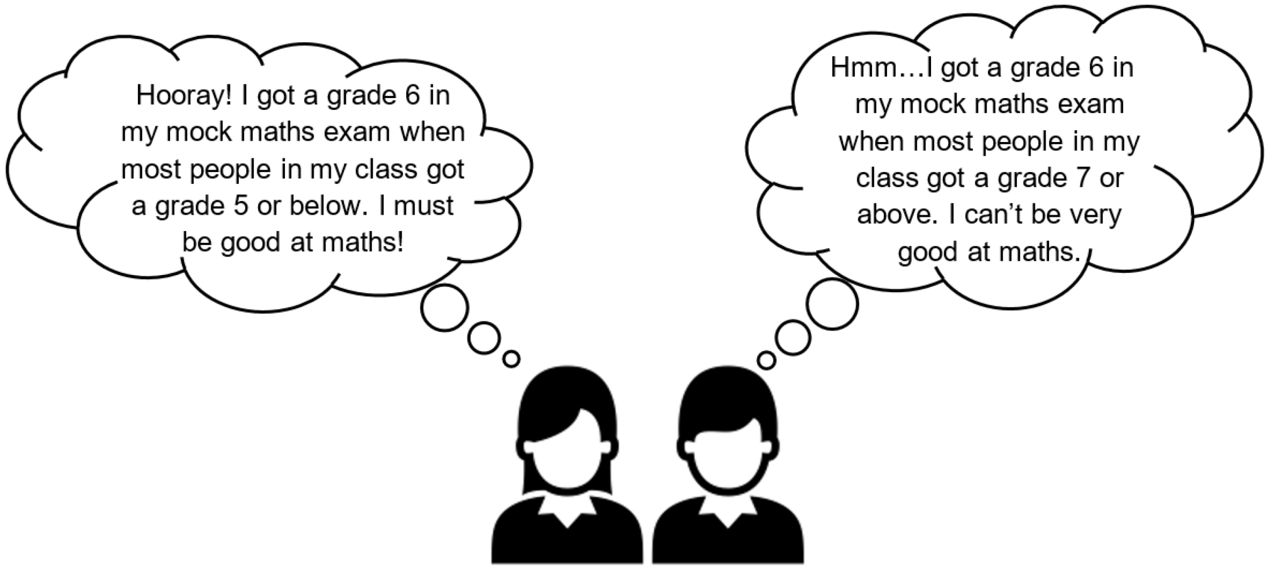
This combines with evidence to show that when people believe they can get better at a subject through effort, they try harder, challenge themselves, carry on when things are difficult, learn from feedback, ask for help and...ultimately...they *do* become much better at the subject.




**Remember: If you put effort into science and maths, you *will* improve.**

2. Don't judge your performance against other people

It is common for students at different schools to perform equally well at science and maths but judge their performance differently. This is because they are comparing themselves to their classmates, which isn't a good idea as it can result in students wrongly believing they are less capable than they are (just like the person on the right in the image below).

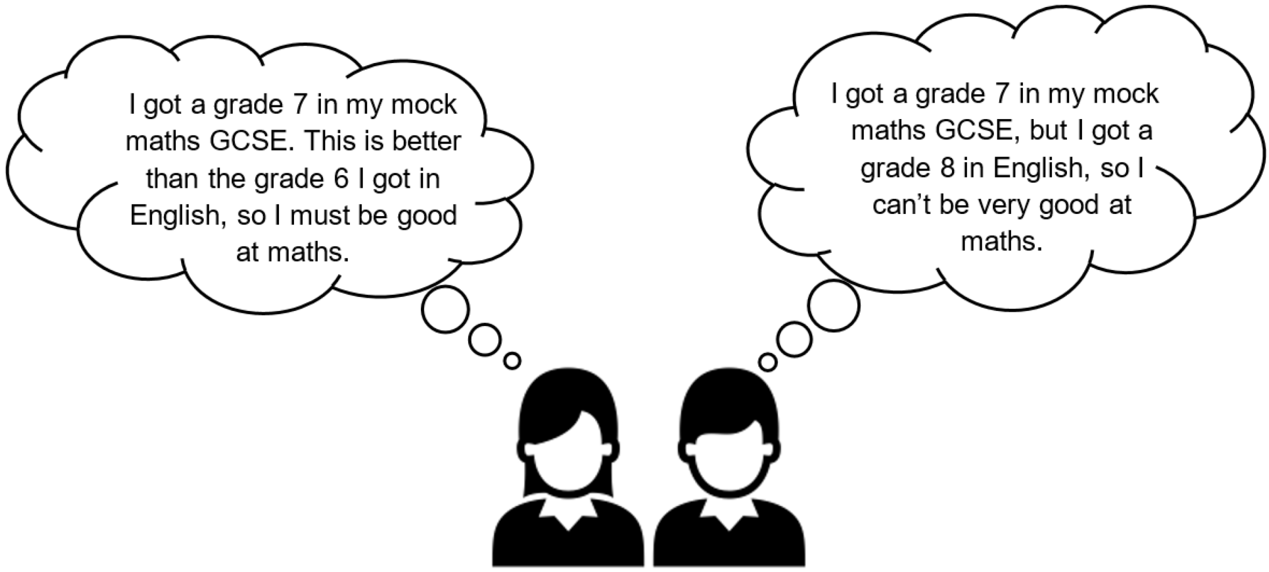



**This matters, as beliefs influence performance.** People who think they are bad at a subject often don't put in as much effort and get distracted by thoughts of failure. This tends to make them perform worse than they otherwise would. However, when people believe that they can do well, they put in effort and find it easier to concentrate, which helps them to learn more and do better.

**Remember: Thinking you can do something can actually make this a reality.**

<u>3. Track progress in that subject over time</u>

Another common mistake people make when considering their performance in maths, science or technology is to compare how well they are doing in these subjects to how well they are doing in other subjects.




Some people mistakenly think that students are unlikely to be good at verbal subjects, like English, as well as maths, science and technology. **This is not true!**

Doing well at English or humanities does **not** mean that maths and science are not ‘for you’, nor the other way around.

Many schools require a grade 6 at GCSE for students to take a STEM subject at A Level. If someone is on track for this, they must, therefore, be doing unusually well in that subjec

**Remember: Don’t make comparisons to other people or to yourself in other subjects -- keep the focus on your own progress in one subject over time.**

**Section 2.**

<u>Share what you know with other students.</u>

As an example, here is a message from a current A Level student who is studying Biology, Chemistry, Government & Politics, and Economics:

*“When you’re studying Chemistry, for example, don’t think about the person sitting next to you and what they’re getting or the person behind you and what they’re getting. Think about what you’re getting out of the subject.*

*Immerse yourself in what you do and keep asking why - keep probing your brain to learn further and do more research and gain the knowledge.*

*Most importantly, never give up. For me personally, taking STEM [subjects related to Science, Technology, Engineering and Maths] isn’t exactly easy, and there are going to be times when you feel like you can’t do it, but the only way to get success is to get up after failure. It doesn’t matter if you found a topic really hard. All you need to do is go back over it and think, “What could I do to learn better?” Or go and ask someone for help - someone who understood it better. And in that way, when you keep improving, you will be successful. Success isn't the first time you try and you succeed. Failure is only failure when you don’t get back up again.”*

Messages from current students can help future students do better. Please write a message to help younger students believe in their ability to do well in science, maths and/or technology.

Try your best; if you agree to it, your response could be added to a bank of messages, like the one you just read - *from* students *to* students - and used to inspire other people.

**Please write your own message, for younger students, in the box below.**

Can you include the three main points from the previous section? You can press ‘Back’ to remind yourself of these three main points at any time. Can you draw on examples from your own experience (e.g. when effort has paid off for you)?

Please spend about 5-10 minutes on your answer. Don’t worry about spelling, grammar or punctuation in this exercise - any mistakes will be automatically corrected afterwards; just get your thoughts down.

[untick if don’t want your answer to be shared with future students]

## Exercise 2 Utility

*Designed to counteract girls' tendency to believe that STEM is not 'for them' and is not relevant for their future*

**Section 1: Recap**

The previous exercise in this series was about people's beliefs in their own abilities in STEM subjects. STEM subjects are those related to science, technology, engineering and maths.

To recap, you read about evidence which shows that some students mistakenly think they cannot do well in these subjects and that this can hold them back.

**In the box below, please list two or three things that people should do to help themselves believe in their own abilities in these subjects:**

Some of the things a student can do to make sure they don't have mistaken beliefs about their ability include:

- Reminding themselves of the importance of effort; recognising that abilities in these subjects are not fixed and that the most important things for success are actually hard work, preparation and self-confidence
- Avoiding comparing themselves to other people
- Avoiding comparing their abilities in these subjects to their abilities in other subjects

Remember, applying these three lessons can actually improve performance too.

**Section 2: Why it matters**

It matters if someone wrongly believes that they can't do STEM subjects or assumes these subjects are not 'for them'; it makes them more likely to miss out on the benefits of continuing to study them after GCSEs. In this activity, you will reflect on the relevance of STEM A Level subjects - maths, physics, chemistry, biology and computer science - to real life: how they are actually useful.

*University and jobs*

As the world becomes more and more dependent on technology, the number of careers that require expertise in maths, science and/or technology is rising faster than any other kind of career. This means that students who have A Levels in maths, science and/or computing are in a very good position to get highly paid jobs.

Even if you decide that a career in these areas is not for you, maths, further maths, physics, chemistry and biology A Levels are among the subjects most highly regarded by leading universities. Students who take these subjects are attractive candidates for a wide range of competitive university degree places, not only those that are obviously related to science and maths.

*Making a difference*

Science, maths and computer science A Levels not only open up a huge number of well paid careers, but also plenty of opportunity to make a real difference in the world. By pursuing science, maths or computer science A Levels, you could:

- Design and construct different types of building and living spaces as an architect or engineer
- Reduce crime by, for example, becoming a forensic psychologist or using technological expertise to address cyber crime
- Treat and cure patients as a doctor, nurse or dentist
- Help people with their mental health, by specialising in psychiatry
- Help generate new solutions for climate change or treatments for disease
- Educate future generations by teaching in schools or universities

These are just a few examples, there are many more and most involve working in teams with talented and creative people.

*Daily life*

The things you learn in STEM A Levels are relevant for daily life. For example, they can improve your:

- health and wellbeing (through understanding nutrition; medical advice; how to avoid food poisoning, sickness, disease, infection and sun damage; how to improve your sleep or reach your fitness goals),
- wealth (by helping you save money, manage money and avoid scams)
- ability to interpret news media and to spot fake news. STEM A Levels also help us understand the world around us and give us knowledge about how things in everyday life work, which makes us informed citizens.

**Section 3: What other students say**

Having read some of the reasons why maths, science and technology are important in general, you can now read statements from former students about the ways in which they find these subjects useful.

Consider if these points could apply to your own life...now, or one day in the future.

**A:** “It’s really cool to be able to work in groups during lab work, and also to try to understand stuff in a group. It’s really good for you if you can learn how to explain a concept to someone else, cause that means that you’re learning and also that you understand it really deeply; you need to be able to do that in order to be able to explain it to someone else.”

**B:** “I think STEM A Levels are really relevant to the real world because they underpin most things in the world. Biology teaches you how everything that’s living works. Computing teaches you about computers and the apps that we use. I feel STEM subjects are really closely tied with how we live our lives.”

**C:** “One of the ways I’m finding STEM A Levels useful is in how it makes you think and how it progresses your mind. I’m learning a lot of transferable skills for the future, such as statistics, problem solving and analytical skills. And that’s going to be useful for jobs centred in almost every industry, such as media, finance and engineering.”

**D:** “In every company that you go to, there is a department for jobs that are connected to STEM, like finance and tech departments. But if I were to take history, there’s not a history department in a workplace. So it’s beneficial to do STEM subjects because there is a job available: 100%...you’re in need! People are looking for people who have the knowledge to take this generation into the next one!”

**E:** “It is really inspiring and motivating for me when I can use my maths, science and tech skills to make a difference. I’m working on developing new materials that can be used to replace bone in the body. People often tell me stories from their own lives, like they’ve got a relative who has problems with their joints. They’re always really excited to hear about what I do and when it might be something which is actually used in the NHS.”

1) Having read those quotations, take a minute to think about your own experiences. Have you heard similar points about these subjects made by others or had any of these ideas yourself before? If so, which ones and in what situation?

2) Of the five statements, which ones can you most relate to? What is it that convinces you about the statements you chose?

3) Rank how important you personally find the quotations from least to most important and explain your ranking in detail.

4) Can you contribute your own statement? Write about why maths, science and/or technology are important to your life; think about the ways in which these subjects are, or could be, useful for you in terms of everyday situations, education, university and/or your professional life.

Consider talking to your parent/carer about the ways that the maths, science and/or technology that you learn in school can be useful in life, and the value of carrying on with these subjects after Year 11. Talking with them may help you discover new connections between these subjects and the things that really matter to you.

**Figure 5** Screenshot of an example from exercise 2 - 'What other students say'


### Exercise 3 Purpose for taking STEM

*Designed to motivate students to engage with STEM and, in particular, to counteract the stereotype that STEM does not involve working with others, helping people and making a difference to the world, which are goals especially endorsed by girls.*

**Section 1. Reflection**

Think about the world, your future and what is important to you.

Everyone thinks that the world could be improved in one way or another. Some people think the most important change would be less hunger, some think greater fairness, and others want less violence or disease. Other people want lots of other changes. Please take a minute to consider ways that *you* think the world could be improved.

**How do you think the world could be a better place?**

In the space below, write a few sentences that answer this question. This should take you about 5 minutes.

Thank you for sharing your thoughts.

---

**Section 2. What other students say**

Many students, girls and boys, choose to take maths, further maths, biology, chemistry, physics and/or computer science at A Level. These subjects are known as STEM subjects (which stands for Science, Technology, Engineering and Maths).

STEM subjects can lead to a wide range of career opportunities, for example:

- Designing and constructing different types of building and living spaces as an architect or engineer
- Reducing crime by, for example, becoming a forensic psychologist or using technological expertise to tackle cyber crime
- Treating and curing patients as a doctor, nurse or dentist
- Helping people with their mental health, as a psychiatrist
- Helping generate new solutions for climate change or treatments for disease
- Educating future generations by teaching

---

A recent survey highlights some of the less obvious reasons students choose to continue with STEM subjects at A Level, in addition to getting a well-paid job:

- All students thought that they could use the knowledge and skills they learn from STEM A Levels to help to make a difference in the world
- 6 in 10 said that students studying STEM subjects are more likely to develop knowledge and skills to make a difference in the world than students studying humanities
- All students believed that STEM A Levels could help them to get a job that involves helping people
- All said that STEM A Levels are well-respected by universities
- 7 in 10 said that taking STEM A Levels increases your chances of getting into a good university
- All stated that STEM A Levels could help them get a job where they work in a team

---

It's often more interesting to hear about people's experiences in their own words. Read on to hear what other students said about their interest in STEM. Afterwards you will be asked to share your own thoughts.

*"STEM subjects are those that make the greatest impact on society. It leads to professions such as medicine, engineering, biotechnology, economics...and these are*

*the subjects that have the greatest impact on people. Being part of this group is a great privilege."*

*"[STEM A Levels] provide skills that are relevant in many areas e.g. teamwork. They also allow progression onto courses that directly aid people e.g. research or healthcare."*

*"Tech makes our lives more efficient so that's why I want to study towards getting a job in the Tech industry. It simplifies our lives."*

*"Society benefits from having more people who understand science and maths and can think critically. A new invention may seem far-fetched but, in reality, people are out there inventing and developing techniques right now that will be changing lives in years to come. STEM A Levels open up the possibility of a job you might not know exists (at least not yet!)"*

*"Current advances in technology will have a positive impact on people's lives. We can improve communication, improve the lives of those with a disability and hopefully widen education to poorer countries."*

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**Section 3.**

Time to share your thoughts

Think about the kind of person you want to be in the future and the kind of positive impact you want to have on the people around you or society in general.

Try not to concentrate on outcomes such as money, high status, or power—even though those things can be important. Instead, try to think about values that are important to how you see yourself, and how doing STEM subjects at A Level could help you to achieve those goals.

To remind you, STEM stands for Science, Technology, Engineering and Maths. The STEM subjects available at A Level include maths (and further maths), biology, chemistry, physics and computer science.

**If you took STEM A Levels in the future, how could they help you become the kind of person you want to be or help you make the kind of impact you want on the people around you or society in general?**

In the space below, write a few sentences that answer this question. This should take you about 5-10 minutes.

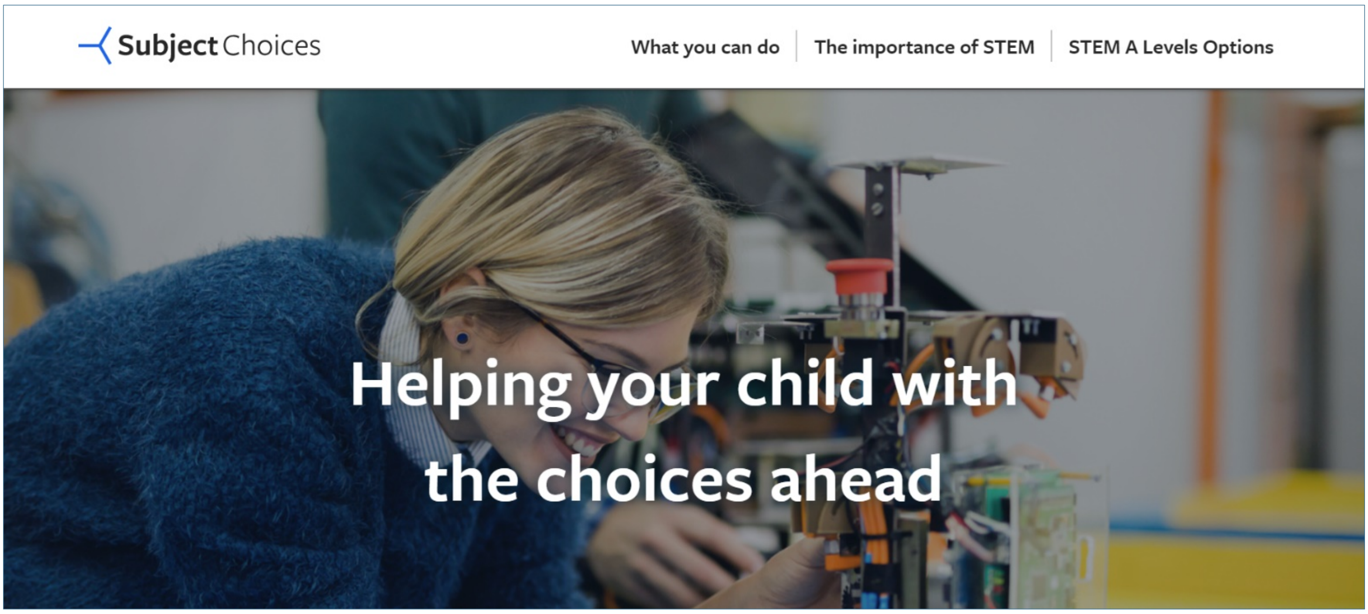
Try your best; if you agree to it, your answer could be shared with future students, like the quotations you have just read.

[untick if don't want your answer to be shared with future students]

## Parent-focused intervention

www.subjectchoices.co.uk

**Figure 6** Screenshot of the landing page of the website parents accessed for the parent-focused intervention



# Annex D

## Results of Very High-Achieving Girls

**Annex Table 1** Overall treatment effect on expectations of success and the perceived utility of STEM subjects for Very High Achieving Girls

| Coefficient Name | Maths (Coef.) | Sig. | Physics (Coef.) | Sig. | Computer Science (Coef.) | Sig. | 1+ STEM subject (Coef.) | Sig. | 2+ STEM subject (Coef.) | Sig. |
|---|---|---|---|---|---|---|---|---|---|---|
| **After treatment** | 0.00 | | 0.01 | | 0.01 | | 0.02 | | 0.00 | |
| | (0.02) | | (0.02) | | (0.01) | | (0.02) | | (0.02) | |
| **Student fixed effects** | yes | | yes | | yes | | yes | | yes | |
| **R2** | 0.93 | | 0.88 | | 0.88 | | 0.85 | | 0.91 | |
| **Mean in pre-treatment** | 0.59 | | 0.18 | | 0.09 | | 0.83 | | 0.63 | |
| ***N=253*** | | | | | | | | | | |

*Data collected through the Behavioural Insights Team's bespoke online platform. Sample restricted to the 253 very high-achieving girls with complete data (those who responded to the survey questions before exercise 1 and then again after exercise 3). Standard errors are reported in parenthesis. * p ≤ 0.05 ** p ≤ 0.01 *** p ≤ 0.001*

**Annex Table 2** Relative impact of different treatments on intentions to study STEM subjects for Very High Achieving Girls

| Coefficient Name | Maths (Coef.) | Sig. | Physics (Coef.) | Sig. | Computer Science (Coef.) | Sig. | 1+ STEM subject (Coef.) | Sig. | 2+ STEM subject (Coef.) | Sig. |
|---|---|---|---|---|---|---|---|---|---|---|
| **After treatment** | 0.00 | | 0.01 | | 0.01 | | 0.01 | | -0.02 | |
| | (0.02) | | (0.02) | | (0.02) | | (0.02) | | (0.02) | |
| **Parent-focused intervention** | -0.99 | *** | 0.51 | ** | 0.00 | | -0.02 | | -0.04 | |
| | (0.18) | | (0.19) | | (0.15) | | (0.2) | | (0.21) | |
| **After treatment * Parent-focused intervention** | -0.01 | | -0.01 | | 0.00 | | 0.03 | | 0.07 | |
| | (0.03) | | (0.04) | | (0.03) | | (0.04) | | (0.04) | |
| **Student fixed effects** | yes | | yes | | yes | | yes | | yes | |
| **R2** | 0.93 | | 0.88 | | 0.88 | | 0.86 | | 0.91 | |
| **Mean in pre-treatment** | 0.59 | | 0.18 | | 0.09 | | 0.83 | | 0.63 | |
| ***N=253*** | | | | | | | | | | |

*Data collected through the Behavioural Insights Team's bespoke online platform. Sample restricted to the 253 very high-achieving girls with complete data (those who responded to the survey questions before exercise 1 and then again after exercise 3). Standard errors are reported in parenthesis. * p ≤ 0.05 ** p ≤ 0.01 *** p ≤ 0.001*

**Annex Table 3** Overall treatment effect on expectations of success and the perceived utility of STEM subjects for Very High-Achieving Girls

| Coefficient Name | I know I can learn the material we cover in maths or science (Coef.) | Sig. | I believe I can be successful in maths or science (Coef.) | Sig. | I can apply what I learn in maths or science class to real life (Coef.) | Sig. | I think maths or science will be important to my future (Coef.) | Sig. |
|---|---|---|---|---|---|---|---|---|
| After treatment | -0.06 | | 0.01 | | 0.19 | ** | -0.05 | |
| | (0.06) | | (0.06) | | (0.06) | | (0.06) | |
| Student fixed effects | yes | | yes | | yes | | yes | |
| R2 | 0.79 | | 0.82 | | 0.81 | | 0.84 | |
| Mean in pre-treatment | 4.84 | | 4.64 | | 4.01 | | 4.78 | |
| *N* | *286* | | *284* | | *284* | | *285* | |

*Data collected through the Behavioural Insights Team's bespoke online platform. Sample restricted to the very high-achieving girls with complete data (those who responded to the survey questions before exercise 1 and then again after exercise 3). Standard errors are reported in parenthesis. * p ≤ 0.05 ** p ≤ 0.01 *** p ≤ 0.001*

**Annex Table 4** Overall treatment effect on self-reported discussions with parents/guardians for Very High-Achieving Girls

| Coefficient Name | I have had at least one conversation with a parent or guardian about my A level choices in the last month (Coef.) | Sig. | I have talked to a parent or guardian at least once about the importance of maths or science in the last month (Coef.) | Sig. |
|---|---|---|---|---|
| After treatment | 0.00 | | -0.02 | |
| | (0.03) | | (0.03) | |
| Student fixed effects | yes | | yes | |
| R2 | 0.76 | | 0.75 | |
| Mean in pre-treatment | 0.65 | | 0.43 | |
| *N* | *284* | | *285* | |

*Data collected through the Behavioural Insights Team's bespoke online platform. Sample restricted to the very high-achieving girls with complete data (those who responded to the survey questions before exercise 1 and then again after exercise 3). Standard errors are reported in parenthesis. * p ≤ 0.05 ** p ≤ 0.01 *** p ≤ 0.001*

**Annex Table 5** Relative impact of different treatments on expectations of success and the perceived utility of STEM subjects for Very High-Achieving Girls

| Coefficient Name | I know I can learn the material we cover in maths or science (Coef.) | Sig. | I believe I can be successful in maths or science (Coef.) | Sig. | I can apply what I learn in maths or science class to real life (Coef.) | Sig. | I think maths or science will be important to my future (Coef.) | Sig. |
|---|---|---|---|---|---|---|---|---|
| **After treatment** | -0.03 | | 0.03 | | 0.21 | ** | -0.02 | |
| | (0.07) | | (0.07) | | (0.08) | | (0.07) | |
| **Parent-focused intervention** | -0.44 | | 0.53 | | -1.97 | ** | -1.46 | * |
| | (0.69) | | (0.66) | | (0.75) | | (0.70) | |
| **After treatment * Parent-focused intervention** | -0.11 | | -0.05 | | -0.06 | | -0.08 | |
| | (0.12) | | (0.12) | | (0.13) | | (0.12) | |
| **Student fixed effects** | yes | | yes | | yes | | yes | |
| **R2** | 0.79 | | 0.82 | | 0.81 | | 0.84 | |
| **Mean in pre-treatment** | 4.84 | | 4.64 | | 4.01 | | 4.78 | |
| ***N*** | *286* | | *284* | | *284* | | *285* | |

Data collected through the Behavioural Insights Team's bespoke online platform. Sample restricted to the very high-achieving girls with complete data (those who responded to the survey questions before exercise 1 and then again after exercise 3). Standard errors are reported in parenthesis. * $p \leq 0.05$ ** $p \leq 0.01$ *** $p \leq 0.001$

**Annex Table 6** Relative impact of different treatments on self-reported discussions with parents/guardians for Very High-Achieving Girls

| Coefficient Name | I have had at least one conversation with a parent or guardian about my A level choices in the last month (Coef.) | Sig. | I have talked to a parent or guardian at least once about the importance of maths or science in the last month (Coef.) | Sig. |
|---|---|---|---|---|
| **After treatment** | -0.03 | | -0.02 | |
| | (0.03) | | (0.04) | |
| **Parent-focused intervention** | 0.96 | ** | 0.00 | |
| | (0.33) | | (0.35) | |
| **After treatment * Parent-focused intervention** | 0.08 | | 0.00 | |
| | (0.06) | | (0.06) | |
| **Student fixed effects** | yes | | yes | |
| **R2** | 0.76 | | 0.75 | |
| **Mean in pre-treatment** | 0.65 | | 0.43 | |
| ***N*** | *284* | | *285* | |

*Data collected through the Behavioural Insights Team's bespoke online platform. Sample restricted to the very high-achieving girls with complete data (those who responded to the survey questions before exercise 1 and then again after exercise 3). Standard errors are reported in parenthesis. * p ≤ 0.05 ** p ≤ 0.01 *** p ≤ 0.00*

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