

How can we increase girls' uptake of maths and physics A-level?

Rachel Cassidy
Sarah Cattan
Claire Crawford
Siobhan Dytham

How can we increase girls' uptake of maths and physics A-level?

Rachel Cassidy
Sarah Cattan
Claire Crawford
Siobhan Dytham

Published by

The Institute for Fiscal Studies

ISBN 978-1-912805-08-2

This research was funded by the STEM Skills Fund, with co-funding from the ESRC-funded Centre for the Microeconomic Analysis of Public Policy (ES/M010147/1).

We acknowledge the funding from the European Research Council (ERC) under the European Union's Horizon 2020 research and innovation programme (grant agreement No 695300 - HKADeC - ERC-2015-AdG/ERC-2015-AdG).

Executive summary

There is a large gender gap in the likelihood of taking maths and physics at A-level, even among high-achieving pupils. Among pupils who achieved grade A or A* (equivalent to grades 7-9) in GCSE maths in 2010, **36.5% of girls compared to 51.1% of boys took maths A-level**. Among those who achieved grade A or A* in GCSE physics, just **13.2% of girls compared to 39.3% of boys took physics A-level**. By contrast, there is almost no gender gap in the likelihood of taking chemistry A-level amongst those who score highly in the subject at GCSE, and girls are actually more likely to take biology A-level than boys.

In partnership with the STEM Skills Fund, **we conducted a study to understand the barriers that stop girls from taking maths and physics at A-level**. This took the form of a small-scale randomised control trial in which girls in Year 11 who were predicted to achieve at least grade 7 (equivalent to at least grade A) in maths, physics or combined science GCSE were offered financial support in return for applying to study physics or maths A-level. As part of this trial, we surveyed 266 girls, as well as a senior staff member across 40 schools, about girls' A-level subject choices and what drives them. We also conducted four focus groups with 6-8 girls in schools in Bolton, Hull, Birmingham and Portsmouth to discuss these reasons in more detail.

Key findings

A majority of girls report enjoying maths and physics, but some find the content and assessment methods off-putting, and are less happy with the quality of physics than maths teaching

77% of girls say they find maths interesting, and 83% report enjoying it, compared to 61% saying that they find physics interesting and 57% saying that they enjoy physics. Three quarters of girls report that the quality of maths teaching they have experienced so far is very good or outstanding, compared to just 38% who say the quality of physics teaching is similarly high. **The focus groups highlighted girls' discontent with the style of teaching for maths and physics.** Girls felt that there was a lot of content to be covered, meaning that the teaching often had to focus on exam preparation, which they felt was boring and repetitive, and meant that they could not go into depth on topics they found interesting.

Low confidence, especially in physics, appears to be a factor explaining girls' reluctance to take maths and physics at A-level

Despite the fact that all of the girls in our sample are predicted to achieve grades 7-9 (A/A*) in maths, physics or combined science at GCSE, 50% of girls agree or strongly agree that "I often worry that it will be difficult for me in physics classes", compared to 25% for maths. **52% agree or strongly agree that "I worry I will get poor grades in physics", compared to 38% in maths.** This may partly be explained by the fact that the girls in our study are predicted to do better in maths than physics at GCSE: 60% of those taking maths and physics GCSEs are predicted to achieve a higher grade in maths than physics and just 8% are predicted to get a higher grade in physics than maths.

Girls perceive STEM careers to be well-remunerated but male-dominated; they are also concerned about taking STEM subjects at A-level and university because few other women do so

92% agree or strongly agree that "working in a STEM job would enable me to make a good living". However, **67% agree or strongly agree that "STEM jobs are male dominated"**, with girls in the focus groups citing male dominance and boys' behaviour in the classroom as reasons for not pursuing STEM subjects at A-level or university. This concern about being in the minority was also perceived by teachers, with 68% of teachers agreeing or strongly agreeing that "these girls don't want to/feel discouraged from pursuing STEM subjects at A-level because many of their female peers do not".

The scholarship appears to have a large (but likely overestimated) impact on applications to take maths and physics at A-level

13.2% of girls in treated schools report taking maths, physics or both as a result of the scholarship. This is to be compared with **57.7% reporting they would have chosen maths or physics anyway.** However, the girls who responded to our questionnaire – on whom these estimates are based – are substantially more likely to have applied for A-level maths or physics than those who did not respond to the survey. This, together with the small sample sizes on which these estimates are based, leads us to be cautious about whether such effects could be replicated in a larger trial. We also do not yet know whether the higher application rates will translate into higher numbers actually studying these subjects.

It seems unlikely that the scholarship alone will be able to tackle the root causes of girls' reluctance to study maths or physics beyond GCSE level

Some girls in the focus groups saw the scholarship as a reward for taking on the demanding nature of maths and physics. However, these students were in a minority and a substantial proportion of the girls responding to the questionnaire felt that no amount of money could induce them to study maths or physics. These girls suggested that **talks from female role models in STEM, STEM work experience, and interventions to build girls' confidence in maths and physics** could be more effective in encouraging them to study maths and physics.

1. The STEM gap at A-level

There is a striking gender gap in the proportion of pupils pursuing maths and physics to A-level, which has persisted over time. Among students taking A-levels in 2017 – the most recent national data available – **18% of girls compared to 33% of boys took maths A-level**, and **just 4% of girls compared to 17% of boys took physics A-level**. By contrast, the gap is just two percentage points for chemistry - 13% of girls and 15% of boys took chemistry A-level in 2017 – and slightly more girls than boys took A-level biology (19% of girls compared to 14% of boys).¹

This report provides insight into what explains these gender gaps in the likelihood of taking maths and physics A-level. We also describe the results of a small pilot trial, funded by the STEM Skills Fund, whose aim was to explore whether financial incentives might help to reduce these gender gaps.

Achievement at GCSE does not explain the gap

It is clear from the national statistics that these large gender differences in the likelihood of taking maths and physics at A-level do not arise because of gender differences in prior attainment. **Attainment in maths and physics at GCSE is very similar for girls and boys: 19.4% of girls taking maths at GCSE in 2017 achieved grades 7-9 (equivalent to A/A*), compared to 20.7% of boys; whilst 41.8% of girls taking physics at GCSE achieved grades 7-9, compared to 42.3% of boys.**² Nor is the gap in physics explained by a difference in the proportion of girls versus boys taking physics as part of triple science at GCSE: 24.0% of girls and 23.2% of boys took physics (rather than combined science) GCSE in 2017.³

As we would expect given these statistics, **the gap in taking maths and physics to A-level is present even among students who achieve grades 7-9 (A/A*).** This is illustrated in Figure 1, which uses data from an older cohort (those taking their GCSEs in 2010).⁴ Among pupils who achieved grade A or A* in GCSE maths in 2010, 36.5% of girls compared to 51.1% of boys took maths A-level. Among those who achieved grade A or A* in GCSE physics, just 13.2% of girls compared to 39.3% of boys took physics A-level. The gap is very similar when looking specifically at pupils from low-income backgrounds (those eligible for free school meals at age 16). Of course, it is important to note that sample selection into achieving a high GCSE grade may be different for girls and boys, for example, given that girls outperform boys at GCSE in general, it may be that only those boys who are very keen on science get an A/A* at GCSE.

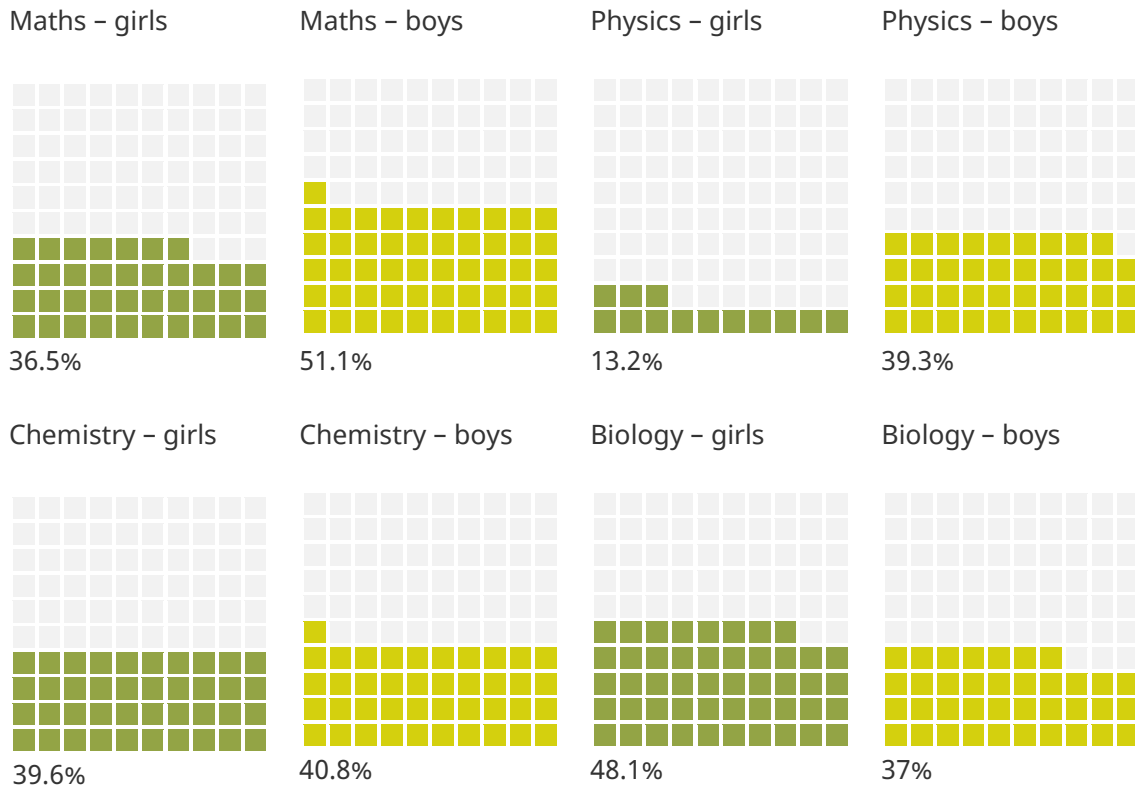
¹ Source: Table 11B of the maths and Science Tables accompanying SFR03/2018, available here: <https://www.gov.uk/government/statistics/a-level-and-other-16-to-18-results-2016-to-2017-revised>.

² Source: Subject Time Series accompanying SFR01/2018, available here: <https://www.gov.uk/government/statistics/reviced-gcse-and-equivalent-results-in-england-2016-to-2017>.

³ Calculated from Table S1a of the Subject Tables accompanying SFR01/2018 (ibid).

⁴ We use individual-level data from the National Pupil Database to undertake these calculations. We do this because there is no publically available national data on the proportion of students with given levels of prior attainment who go on to take different subjects at A-level, and this is the most recent data containing the information we need to which we had access.

Figure 1. Proportion of pupils taking A-level in 2010, conditional on A/A* at GCSE



Note: based on a census of pupils in England taking GCSEs in 2010.

By contrast, as we would expect given the small overall gender differences in the likelihood of taking chemistry and biology A-level, **there is almost no gap in the likelihood of taking chemistry A-level between boys and girls who perform well in chemistry GCSE**: 39.6% of girls who achieved grades A or A* in GCSE chemistry in 2010 went on to take chemistry A-level, compared to 40.8% of boys. And girls who achieved highly in GCSE biology were actually more likely to take A-level biology than similarly achieving boys: 48.1% of girls who achieved grade A or A* went on to take biology A-level compared to 35.7% of boys.

The remainder of this report explores which other factors might be important in explaining why high achieving girls are less likely to take maths and physics A-level than high-achieving boys, and hence what types of interventions might be most successful at reducing the gender gaps. Section 2 describes the pilot trial and the data underpinning the findings described in this report. Section 3 discusses the results from an online questionnaire designed to elicit information on girls' A-level subject choices and what drove their decisions. Section 4 describes what we can learn from a small pilot trial, which explored whether financial incentives might be one route through which to reduce the gender gaps in take-up of maths and physics A-level.

2. Study methodology

Sample

In September 2017, the STEM Skills Fund invited by email all state secondary schools in England to express interest in participating in a trial of a scholarship designed to encourage high-achieving girls in maths and/or physics GCSEs to continue studying these subjects at A-level.

Around 400 schools responded positively to this initial email. These schools were then re-approached to provide information on the number of girls in their school that met the eligibility criteria for the scholarship, i.e. who were predicted to achieve at least a grade 7 (equivalent to at least a grade A) in maths, physics or combined science GCSE, and how they were split between those who were and were not eligible for free school meals. 233 schools responded to this additional request for information.

As we might expect, these schools are not representative of all secondary schools in England. They have higher average Key Stage 4 outcomes, and a lower percentage of students who are eligible for free schools. A higher proportion of them are selective schools, faith schools and single sex schools. Students from these schools are also more likely to study maths and physics at A-level even before the scholarship was introduced.

Having undertaken power calculations on the basis of baseline continuation rates, likely treatment effects and the estimated numbers of eligible students per school, it was decided that a small pilot trial should be conducted, as proof of concept, and to learn more about the factors underlying girls' A-level subject choices,

We randomly selected a subsample of 48 schools and invited them to participate in this phase of the study. These schools were asked to sign a Memorandum of Understanding with the IFS and the STEM Skills Fund, setting out the expectations on both sides. Specifically, schools were told that their participation would involve being part of a small, randomised controlled trial of a scholarship pilot. It would also require filling out an online school questionnaire and encouraging the eligible girls in their school to answer a pupil questionnaire and possibly participate in a focus group.

Scholarship pilot

The scholarship was designed to encourage girls who were predicted to do well in maths, physics or combined science GCSE (the eligible students) to stay on to study maths or physics at A-level. It consisted of an upfront payment made to all eligible girls shortly before A-level subject choices were finalised (in January of Year 11) and an additional weekly payment for 12 weeks during the summer term of Year 11 to those eligible girls who applied to study physics and/or maths at A-level. In the pilot, we varied the amount of upfront and weekly payments across schools, to provide indicative evidence on whether the amount and/or timing of the scholarship mattered for its success. Specifically, schools were randomised into either a **control group** (in which no scholarships were provided) or one of **six treatment arms**, as shown in Table 1 below.

Table 1. Pilot trial treatment arms

| Treatment arm | Total scholarship amount | Upfront payment to all eligible girls | Weekly payment to those applying for maths or physics A-level (12 weeks) | Achieved number of schools per treatment arm |
|---------------|--------------------------|---------------------------------------|--|--|
| 1 | High (£480) | High (£192) | £24 | 6 (2) |
| 2 | High (£480) | Low (£96) | £32 | 6 (2) |
| 3 | High (£480) | None (£0) | £40 | 7 (2) |
| 4 | Low (£240) | High (£96) | £12 | 5 (2) |
| 5 | Low (£240) | Low (£48) | £16 | 6 (2) |
| 6 | Low (£240) | None (£0) | £20 | 6 (2) |
| 7 (control) | None | None | None | 7 (3) |

Treatment was stratified on the number of FSM-eligible girls per school. The idea was that in one third of the schools in each treatment arm all girls in Year 11 who were predicted to achieve grade 7 or above in maths, physics or combined science would be eligible for the scholarship, while in the remaining two thirds only girls who met these criteria *and* were 'FSM6' (i.e. had been eligible for free school meals in at least one of the previous six years) would be eligible for the trial.

48 schools were initially randomised into the trial – 12 to the control group and six to each of the six treatment arms. However, not all schools returned a signed memorandum of understanding (MOU) by the deadline set, so we randomly assigned a further 11 schools (8 control and 3 treatment) to try to ensure a full complement of schools in each treatment arm. Due to time constraints, it was not possible to continue doing this until a full complement of schools was achieved, so in total 43 schools returned MOUs (36 from the treatment group and 7 from the control group) and were officially included in the pilot. Table 1 shows how this was split by treatment arm, with the number in brackets indicating the number of schools in which all girls were eligible for the scholarship.

It is important to note that the pilot trial was not designed to produce strong statistical conclusions with respect to the effect of the scholarship. Many more schools would have been necessary for this. The small sample sizes that we have, together with the fact that we have some non-response to our invitation to participate in the trial which disproportionately affects the control group, undermines our ability to use a simple comparison of average outcomes across the treatment and control groups to produce an unbiased estimate of the treatment effect. As an illustration of this point, the historic continuation rates of girls achieving at least grade A in maths, physics or combined science GCSE to maths or physics A-level amongst the set of schools actively participating in the trial range from 36% to 63% in the treatment group, and just 39% in the control group. This highlights that comparing application rates for maths and physics A-level between the treatment and control groups is likely to produce a biased estimate of the effect of the scholarship.

Rather, the main goals of the study were to: a) get a qualitative sense of whether varying the timing and amount of money offered to the girls had an impact on their likelihood to pursue maths or physics at A-level; b) gather a sample of schools and girls exposed to the scholarship whom we could survey about the factors that drive the gender gap in STEM; and c) assess the logistical complexities associated with implementing such a study, should a larger one be implemented in the future.

Eligibility for scholarship

We relied on schools to tell us which students were eligible for the upfront and weekly payments. For various reasons, information on which pupils were eligible for the upfront payments was not provided by 1 treatment school and information on which pupils were eligible to receive the weekly payments was not provided by 11 schools. This means that we do not know which pupils applied to study maths or physics in 11 schools (8 – equivalent to a 28% attrition rate - in the treatment group, and 3 – equivalent to a 57% attrition rate - in the control group). This differential non-response rate is problematic, because of course it is not random. We discuss the implications of this in detail in Section 4.

School and Pupil Survey

We designed a school and a pupil questionnaire to understand the barriers that mean girls are less likely to take maths and physics at A-level and shed light on the potential role of various interventions in encouraging more girls to pursue these subjects at A-level. The surveys covered many possible factors affecting girls' choices of A-levels, including teaching, perception of the subjects and of the likelihood of doing well, university and career choices, and role models.

We invited all schools and eligible girls in these schools to fill out their respective online surveys. Because we had no direct contact with the girls, we relied on the schools to pass on the link to the pupil online survey to the girls. Senior staff from 40 schools (i.e. almost all schools in our sample) answered the school questionnaire. The response rate on the pupil questionnaire was much lower, with only **266 girls** out of about 450 eligible girls answering. The response rate greatly varied across schools, from 0% to 100%. We did not get answers from any girls in 11 schools (10 schools in the treatment group and 1 in the control group).

Participation in the questionnaire was voluntary, so it is important to keep in mind that the girls who answered it may not be representative of the sample of eligible girls involved in the study when interpreting the results. Of particular note is that the girls who answered the pupil questionnaire are much more likely to have applied for math or physics A-level than those who did not respond: 65% of those who responded to the questionnaire had applied to study maths or physics A-level, compared to just 27% of those who did not respond.⁵

⁵ As outlined above, schools separately provided the information about which of the eligible students had applied to study maths or physics A-level, as it was on this basis that weekly payments of the scholarship were made.

Focus groups

We also conducted **four focus groups** with 6-8 girls in schools in Bolton, Hull, Birmingham and Portsmouth. The girls were asked to write “things that make you not want to study maths or physics at A-level” and “things that make you want to study maths or physics at A-level” on post-it notes. These were then collected by the facilitator and discussed as a group. At the end of the focus group, the girls were asked “if someone told you that you would receive a bursary for choosing to study maths or physics at A-level, would this change your decision? Why/why not?”

3. Explaining the gender gap

This section summarises the key takeaway messages that were apparent from the surveys and focus groups, about the most important factors driving the gender gap in STEM subjects.

Girls are dissatisfied with teaching style and course design

Overall the teaching of maths and physics A-level appeared to be well-resourced. All but one of the schools in our sample (97%) report that they were offering maths at A-level, and all but two that they were offering physics (95%). 81% and 85% report that all maths and physics teaching respectively is done by specialist teachers with at least an undergraduate degree in their subject. 73% report assigning their best maths and science teachers to A-level. Of course, as outlined in Section 2, these schools are not representative of all schools, and given that they volunteered to take part in the trial and completed the survey, they may place a particularly strong emphasis on maths and physics.

The girls report that the maths teaching they have experienced so far, i.e. to GCSE level, is of good quality, with 76% saying that the teaching was very good or outstanding and just 8% reporting that it was satisfactory or poor (the rest report that it is “good”, which is the middle of the scale). **They are less positive about physics teaching**, with just 38% reporting very good or outstanding teaching, and 30% reporting satisfactory or weak teaching. **The focus groups highlighted girls’ discontent with the style of teaching for maths and physics.** Girls reported that the teaching of these subjects is too focused on exam preparation, which they felt was boring and repetitive and meant that they could not go into more depth on topics that they found interesting:

“[The teaching is] way more going over old stuff than actually learning enough.”

Girls also felt that maths and physics do not provide opportunity for debates or discussion, which did not appeal to some of the girls. Instead they preferred subjects such as English and History where they could have debates or give their opinion:

“I like the concepts in maths and physics but hate the way they are taught.”

Nonetheless, overall 77% of girls report that they find maths interesting, and 83% report enjoying it. The figures for physics are lower, with 61% saying they find it interesting and 57% saying that they enjoy it. Enjoying a subject is by far the most important reason cited by girls for their choice of A-level subjects: 51% say it is the most important reason. In terms of other factors cited by the girls as the most important reason for choosing their A-level subjects, 17% say believing they will perform well, and 17% say that it is a requirement for their chosen university course.

This teaching style may in part stem from the nature of the syllabus. **The girls felt that there was a lot of content in maths and physics GCSE (particularly physics) and they thought that there would be even more content at A-level.** They found this off-putting

as it made the subjects difficult, but also because they felt that the subjects covered breadth rather than depth:

“It was when we were doing space we literally spent one lesson on this topic and it’s a really interesting topic but we couldn’t spend any more, I think it might be to do with the fact that we’re doing the new exams so it’s a bit stressful but it seems like there’s not enough time to really go into depth with what you’re learning so it’s kind of just a bit panicked.”

They also felt that at A-level maths and physics would require them to spend significantly more time on homework and study than other subjects, which some girls found unappealing. That said, the girls felt that A-level maths and physics are well-respected qualifications because of their demanding nature.

Finally, many of the girls found it “intimidating” that maths and physics are assessed entirely by exam at the end of the course. They felt that having some coursework would allow them to show their understanding in other ways and relieve some of the pressure they felt entering final exams. This experience at GCSE put them off the idea of studying these subjects at A-level.

Girls lack confidence in their ability, especially in physics

Related to this, despite the fact that all of the girls in our sample are predicted to achieve grade 7-9 (A/A*) in maths, physics or combined science at GCSE, they report concerns about their ability to perform at A-level, particularly in physics.

- **50% of girls agree or strongly agree that “I often worry that it will be difficult for me in physics classes”, compared to 25% for maths.** 52% agree or strongly agree that “I worry I will get poor grades in physics”, compared to 38% in maths.
- **Just 29% agree or strongly agree that “physics is one of my best subjects”, compared to 69% for maths.** 36% agree or strongly agree that “I learn physics quickly”, compared to 77% in maths.

These concerns may at least partly be rooted in different predicted grades in the two subjects: amongst students who are taking maths and physics GCSEs, 60% are predicted to achieve a higher grade in maths than physics, while just 8% are predicted to get a lower grade in maths than physics (the remainder are predicted to achieve the same grade). The differences are smaller for girls taking maths and combined science GCSE, but it is still the case that more girls are predicted to do better in maths than combined science compared to the converse: 43% are predicted to do better in maths than combined science compared to just 14% who are predicted to do better in combined science than maths.

The girls in the focus groups also admitted worrying about their ability in physics:

“I’m not taking it [physics] at A-level because I don’t really think I’m good at it.”

“Physics jobs seem very interesting, however, I didn’t take it at A-level as I’m not excellent at physics.”

Girls also reported that their concerns were reinforced by having been told by teachers, parents and friends that maths and physics A-levels are 'difficult':

"I chose it [maths] but at first I wasn't going to because people kept telling me that it was too hard."

"...A-level maths and science are known as the 'hardest' A-levels."

Teachers also cite lack of confidence as the biggest factor affecting the gender gap in pursuing STEM subjects to A-level: 80% agree or strongly agree that "these girls are just as able, but not as confident in their ability to learn STEM subjects as boys."

"Male dominance" in the classroom deters some girls

In the focus groups, **girls cited the behaviour of boys in maths and physics lessons as a reason why they do not enjoy learning these subjects, and why they would not want to pursue them further.** Girls gave examples of boys chanting or making noises to intimidate them when they were asked a question by the teacher, or laughing if they gave an incorrect answer. Girls were particularly concerned that they would be in a class of mostly boys both at A-level and university. They knew that this was the case for A-level classes from taster days and speaking to older students:

"When I went to computer science at a taster day and I was one of two girls in the entire classroom and it put me off taking the A-level... I don't want to be in a class again of just mainly boys"

Some girls believed that boys are better at maths and physics than girls. They felt that the fact that more boys take these subjects at A-level was proof of this:

"... it's like traditional that boys are really good at maths and physics so I feel quite not as good as the boys because in my class the best people are the boys."

Some girls also requested that teachers stop doing "boys vs. girls" activities in class:

"I feel like school should stop doing boys against girls competitions because it's just making it more rigid the division."

Teachers also cite concerns that the lack of girls taking STEM subjects to A-level is self-reinforcing: 68% of teachers agree or strongly agree that "these girls don't want to/feel discouraged from pursuing STEM subjects at A-level because many of their female peers do not."

Maths and physics are seen as opening doors at university...

The perception that maths and physics are difficult did lead the girls to perceive that they were valued more highly on university applications:

"I feel like though on uni applications if you're going to uni and they see that maths or physics is on your results they kind of admire that I don't know why I feel like you've got more opportunity to go to uni if that's on there than say with other stuff."

Some of the girls in the focus groups felt that physics, and maths in particular, were good A-level choices if a girl was currently unsure about what she wanted to do in the future, because they could be used for so many different careers/university choices:

“Physics may be a good one to take because it helps with the understanding and physics relates to a lot of things.”

“I chose maths A-level as I’m still not sure of what I want to do in uni so it keeps my options open.”

... but most girls have decided on courses that do not require physics

When asked which subject they would most likely study at university, 18% of girls said medicine, dentistry or veterinary science; 17% said maths; and 8% said law. Just 4% said engineering or technology, and a mere 1% said computer science.

Girls are aware of the benefits of STEM careers, but fear they are “male-dominated”

Girls view STEM careers on the whole very favourably, and perceive STEM jobs as well remunerated:

- 87% agree or strongly agree that “working in a STEM job would enable me to make a positive contribution to society”.
- 92% agree or strongly agree that “working in a STEM job would enable me to make a good living”.

Evidence on girls’ perceptions of their own ability to do well in a STEM career is more mixed:

- 73% agree or strongly agree that “I received high grades in STEM subjects at school, so I could do well at a STEM job.
- 38% agree or strongly agree that “I am not good enough at maths or science to work in a STEM job”

More strikingly, girls believe that STEM jobs are difficult to obtain, especially for women, and that STEM careers are male-dominated:

- 49% agree or strongly agree that “STEM jobs are hard to get, especially for women.”
- 67% agree or strongly agree that “STEM jobs are male dominated”.

Testimony from the focus groups supports the idea that this perception of male dominance is an important concern:

“When we went to college open day my friend wanted to do engineering but she was the only girl so she didn’t want to do it anymore.”

Teachers also perceive that the gender gap in STEM A-level is partly driven by girls not aspiring to work in STEM, and that this is strongly driven by male dominance: 75% agree or strongly agree that “these girls don’t aspire to work in STEM occupations and so don’t need to take A-levels in STEM subjects”; and 80% of those agreeing or strongly agreeing say this is because “STEM occupations tend to be male-dominated”.

Lack of STEM role models also appears to be important. **87% of those teachers who believe that girls do not aspire to work in STEM occupations also say that this is because “they lack female role models working in STEM”.** Just 31% of girls agree or strongly agree with the statement “I know someone who works in STEM, so I know what to expect from a STEM job”. Focus group discussions also reinforced the idea that girls were very aware of general careers information on STEM careers, but wanted more informal information about the day-to-day aspects of the careers and the potential downsides:

“Yeah also with career fairs there’s like they only tell you the positive aspects of a job they never tell you what could be negative about it because obviously they want you to go into that job.”

Insofar as female STEM teachers may serve as important role models, there is some evidence of lower exposure to female physics teachers than to female maths teachers. 90% of girls in our sample have ever been taught by a female maths teacher at some point during high school; whilst 64% have ever been taught by a female physics teacher. Schools report very gender-balanced teaching of maths at A-level; but 34% of schools have no female physics teachers at A-level, compared to 23% who have no male physics teachers.

4. STEM scholarships for girls

As outlined in Section 2, in partnership with the STEM Skills Fund, we piloted a scholarship whose aim was to encourage more high-achieving girls to study maths or physics at A-level. Schools were randomly allocated to the different treatment arms, so in principle we should have been able to compare the average take-up rates for maths or physics A-level in the treatment and control groups in order to estimate any effect of the scholarship on the take-up rates of maths and physics A-level. However, as outlined in Section 2, the sample of schools who accepted our invitation to participate in the trial was not a random subset of those who were invited. Moreover, this was particularly true in the control group. As such, we have some concerns about using such a simple comparison to estimate the impact of the scholarship on the take-up rates of maths and physics A-level.

Instead, we use information collected directly from the survey. As part of the questionnaire, all girls in the treatment group were asked whether the scholarship had induced them to change their A-level subject choices, and if so whether it encouraged them to choose maths or physics or both. This provides a direct assessment of the number of girls who responded to the treatment.

The scholarship appears to have large (but likely over-estimated) impacts on applications for maths and physics A-levels

Altogether 227 girls from the six scholarship treatment arms responded to our questionnaire.

- **13.2% of girls in treated schools (30 girls) report applying for maths, physics or both as a result of the scholarship.** This is compared to **57.7%** of girls in treated schools (131 girls) taking maths or physics A-level, or both, who say that the scholarship did not change their decision and that they would have taken maths or physics anyway. Thus if we take the girls at their word, the scholarships increased take-up of maths or physics by **22.9% (13.2/57.7)** in the treated schools.
- Specifically, **10.6% of girls in treated schools (24 girls) report that the scholarship made them apply for maths A-level when they otherwise would not have done so.** This is compared to **55.5%** of girls in treated schools (126 girls) applying for maths A-level who say that the scholarship did not change their decision and that they would have applied for maths anyway. Thus if we take the girls at their word, the scholarship increased applications for maths A-level by **19.1% (10.6/55.5)** in the treated schools.
- Meanwhile **3.5% of girls in treated schools (8 girls) report that the scholarship made them apply for physics A-level when they otherwise would not have done so.** This is compared to **13.2%** of girls in treated schools (30 girls) applying for physics A-level who say that the scholarship did not change their decision. Thus if we take the girls at their word, the scholarship increased applications for physics A-level by **27% (2.6/13.2)** in the treated schools.

The scholarship appears to change the choices of FSM-eligible girls as much as non-FSM girls: approximately a third of the girls who reported applying for maths, physics or both as a result of the scholarship are FSM-eligible, which matches the proportion among all girls responding to the questionnaire. It is also worth noting that there is no systematic pattern across the treatment arms – i.e. across scholarships with smaller or larger payments, or more or less upfront payment – in terms of how many girls changed their A-level subject choices.

These estimates appear sizeable. However, there are some important caveats that should be borne in mind when considering whether these estimates might be generalizable beyond the scope of the trial. First, the sample size is very small. While we see a 27% change in the proportion of girls applying for maths or physics, this estimate is based on just eight students changing their A-level subject choices. The girls who take up maths or physics as a result of the scholarship also came overwhelmingly from two schools. This may in part be attributable to the fact that these were the largest schools in our sample in terms of the number of eligible girls, but obviously makes it possible that other things going on in those schools – such as other interventions designed to increase participation in STEM subjects, or a new particularly effective maths or physics teacher, for example – might also have contributed to the higher take-up rates that we see.

Second, the sample of girls who responded to the questionnaire are not a random subset of the girls participating in the trial. In particular, as outlined in Section 2, the girls who responded to the questionnaire were substantially more likely to report applying for maths or physics than those who did not respond. This strongly suggests that we might be over-estimating the effectiveness of the scholarship.

To try to provide a sense of how important this bias might be, we make use of the information on whether girls in the treatment groups who did not respond to our survey applied for maths or physics A-level, as this information is reported independently by the schools. Doing so reduces the overall percentage of girls applying to study maths or physics, or both, to 55.1% (from 69.2%)⁶, because the application rates are lower among students who did not respond to the survey than among those who did.

By making some assumptions, we can also use these figures to provide some bounds on the likely treatment effect amongst all girls whose schools provided A-level subject choice information (and not just those who responded to our survey). The most optimistic interpretation of these figures – obtained if we were to assume that all of the girls who did not respond to our survey but who are reported by their schools to have applied for maths or physics A-level were assumed to have done so as a result of the scholarship – would suggest that the scholarship increased the percentage of girls taking maths or physics A-level rose by 20.3 percentage points from a baseline application rate of 34.8% (i.e. by 58.3% (20.3/34.8)). The most conservative interpretation would be to assume that none of the girls who did not respond to our survey but are reported by their schools to have applied for maths or physics A-level did so as a result of the scholarship, but instead would have taken these subjects anyway. If we do this, then the estimated treatment effect

⁶ In the survey, 70.9% of girls report applying to A-level maths, physics, or both; compared to 69.1% in the administrative data provided by schools. This small discrepancy is likely because administrative data is missing for a small number of girls.

would fall to 8.2 percentage points from a baseline application rate of 46.8% (i.e. by 17.5% (8.2/46.8)). Given the size of the treatment effect seen amongst the sample of girls who responded to the questionnaire, the true estimate is likely to fall closer to the latter than the former.

A third reason why we should be cautious about extrapolating these estimates is because we do not know to what extent these differences in application rates will translate into actual differences in completed A-levels. Several schools were keen to get clarification on what would happen if their students later changed their minds about which subjects to study – although it should be noted that this did not apply to either of the two large schools from which the majority of girls reporting that they responded to the scholarship were drawn.

The scholarship may offer girls a reward for undertaking subjects they perceive to be hard

As a possible explanation for the observed effects, **some girls in the focus groups saw the scholarship as a kind of reward for taking on the demanding nature of maths and physics:**

“I think that students think that maths is really hard work and physics and you need to put a lot of effort into it so they feel like they don't do it for nothing at least they see their reward closer to now than in the really future like in a few years.”

Overall, the girls in the focus groups felt that the scholarship might persuade girls who were on the margin of taking maths or physics; but most of them did not identify as such, as they had made their mind up either way ever before Year 11. It does not appear that the scholarship was needed for girls to overcome financial constraints to studying maths and physics at A-level. 98.1% of the girls surveyed were going on to study A-levels anyway, and thus implicitly were not comparing A-level study to the financial benefits of employment or paid training schemes. Moreover, of the girls who had received scholarship payments by the time of the survey, **68% of girls (63% of FSM-eligible girls) reported saving all or part of the money** and 19% (12%) spent all or part of it on non-school items; thus most girls do not appear liquidity-constrained with respect to investing in A-level studies. That said, **27% (45% of FSM-eligible girls) reported spending all or part of the scholarship on school materials**, and 14% (29%) spending all or part of it on tutoring or revision classes.

Are maths and physics better choices for these students?

Over half of the girls who changed their A-level subject choices as a result of the scholarship reported dropping psychology (8 girls), geography (5 girls) or art and design (3 girls) in favour of maths and/or physics. A quarter (7 girls) reported dropping either biology or chemistry. While girls are over-represented in biology relative to boys, and equally represented in chemistry, it would be sensible to ask schools to check that girls switching from other science subjects are aware of any potential implications of doing so (e.g. if they were planning to go on to study medicine, then both

biology and chemistry would typically be required). The remaining few girls dropped subjects including English literature and business.

While the majority of girls in the sample had applied for maths or physics A-level, some in response to the scholarship, **29.1% (66 girls) had not applied to study maths or physics A-level despite being offered the scholarship.** (This figure rises to 44.9% (164 girls) when we include those who did not respond to the survey.) The size of the scholarship did not appear to be the limiting factor for most girls: of these girls, 74% said that even a larger scholarship would not have changed their mind. The 26% who said a scholarship might change their mind mentioned figures in the thousands of pounds. Overall the students in the focus group felt that a bursary would have limited impact because money could not change their feelings towards a subject and girls felt that liking the subject and enjoying their A-level study was more important:

“Money would be good because everyone would enjoy having it but then you’ve got two years of a subject you absolutely hate it’s not worth it.”

“The money that they’re giving you I don’t think it would sort of weigh out the sort of stress or unhappiness that you would have if you were doing physics.”

Some also said that the incentive came too late, as most girls had already thought about what future careers they would like and knew what A-levels they need to take for this.

Possible alternative interventions

The results from the surveys and focus groups highlighted other, potentially low-cost interventions which might increase girls’ pursuit of maths and physics at A-level.

Work experience in STEM

- **98% of teachers think that offering girls work experience in STEM occupations would be effective or very effective.** This is compared to just 73% who think that offering girls financial support during year 11 would be effective or very effective. Only 43% of schools currently have links to businesses in STEM, suggesting that it might be necessary to broker relationships with new businesses or to deepen the existing relationships in order to achieve such an aim.
- Of the girls not going on to study STEM subjects at A-level, this was also the most popular suggested intervention, with 37% saying that they thought work experience in STEM would be useful.

Female role models

- **Similarly, 98% of teachers think that helping girls to access female role models working in STEM occupations would be effective or very effective** in closing the gender gap in the take-up of A-levels in STEM subjects.
- Indeed, 33% of the girls who are not going to study STEM subjects at A-level say that meeting women who work in STEM could make them more interested in pursuing STEM at A-level. At one school, the girls gave a specific example of a visiting speaker and explained that they found it inspiring because she was young, female and had attended the same school as them:

“We had this female speaker come in and it wasn’t about maths it was about Business, do you remember, and that was I found that really inspiring so if we had more female successful people in Science and maths I think it would inspire people because I don’t even take Business but I was like I want to be a Businesswoman”

Confidence building

- **Interventions to boost girls’ confidence, especially in physics, could also play an important role.** In the focus groups, the girls highlighted the particular need for **supportive teachers**. Given girls’ concerns about performance at A-level, another option might be to **provide girls with tailored statistics on the proportion of girls like them who do go on to achieve an A/A* at A-level**. This information would be straightforward to obtain and hence could provide an option for a very low cost alternative or additional intervention to trial in future.