Robotics Challenge:
2021/22 evaluation findings

October 2022

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Introduction

Robotics Challenge is a STEM programme for young people aged 10 to 14. Participants learn in school how to build, program and control autonomous LEGO® robots and complete a series of short, environmental engineering missions. Teams then have the option of entering the Robotics Challenge heats, whose winners compete at the UK final as part of the annual Big Bang Fair.

In 2021/22:

321 schools engaged in the programme

153 schools took part in the Robotics Challenge heats

39 schools competed at the UK finals

This report presents feedback from students and teachers who took part in the Robotics Challenge programme in 2021/22, gathered via a mix of online and in person surveys as well as through virtual and face-to-face interviews.

Feedback from students enables us to better understand their experiences and any impact they feel the programme has had on their skills, their interest in engineering careers or in taking part in more STEM related activities. It also helps us to explore more generally their attitudes towards STEM and whether there are differences in overall programme experience based on students' gender, ethnicity or eligibility for free school meals (FSM).

Feedback from teachers provides insights into their perspective on the programme's impact for students, any additional benefits for the school, and what they feel they have gained from participating.

This information allows us to continually improve the programme and the processes of delivering it, and to gain some understanding of how far the programme is meeting its aims of informing and inspiring young people into further STEM study and careers.

We also ask for teachers' recommendations and suggestions for further inspiring young people in STEM. These views help to shape future iterations of this programme and the wider work of EngineeringUK.

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Who responded to the student surveys?

Students were invited to take part in our survey at 10 Robotics Challenge heats in April and May 2022, using iPads at in-person events or online at the virtual heat. Teams were asked to complete the survey after participating in at least two of the five challenges that make up a heat.

Each heat had between 3 and 10 schools attending. We had good engagement with data collection, with around 90% of students at each heat completing a survey. The table below provides a breakdown of the demographics of students who completed a survey.

		Students who completed the survey	
		Number	**%**
Total		434	
EDI school[1]	Yes	219	50%
	No	200	46%
	Missing	15	3%
Year Group	Year 7/S1	137	33%
	Year 8/S2	142	34%
	Year 9/S3	141	34%
Gender	Female	179	43%
	Male	211	50%
	Non-binary or other self-description	20	5%
	Prefer not to say	10	2%
Ethnic groups	Asian/Asian British	61	15%
	Black/Black British	24	6%
	Mixed or multiple ethnic groups	25	6%
	White	277	66%
	Other ethnic identity	9	2%
	Prefer not to say	23	5%
Receive Free School Meals	Yes	32	8%
	No	370	88%
	I don't know	15	4%
	Prefer not to say	3	1%

1. Equality, Diversity and Inclusion criteria, based on student population with higher numbers from groups typically under-represented in engineering. For more detail, see EngineeringUK EDI Criteria - Tomorrow's Engineers (tomorrowsengineers.org.uk)
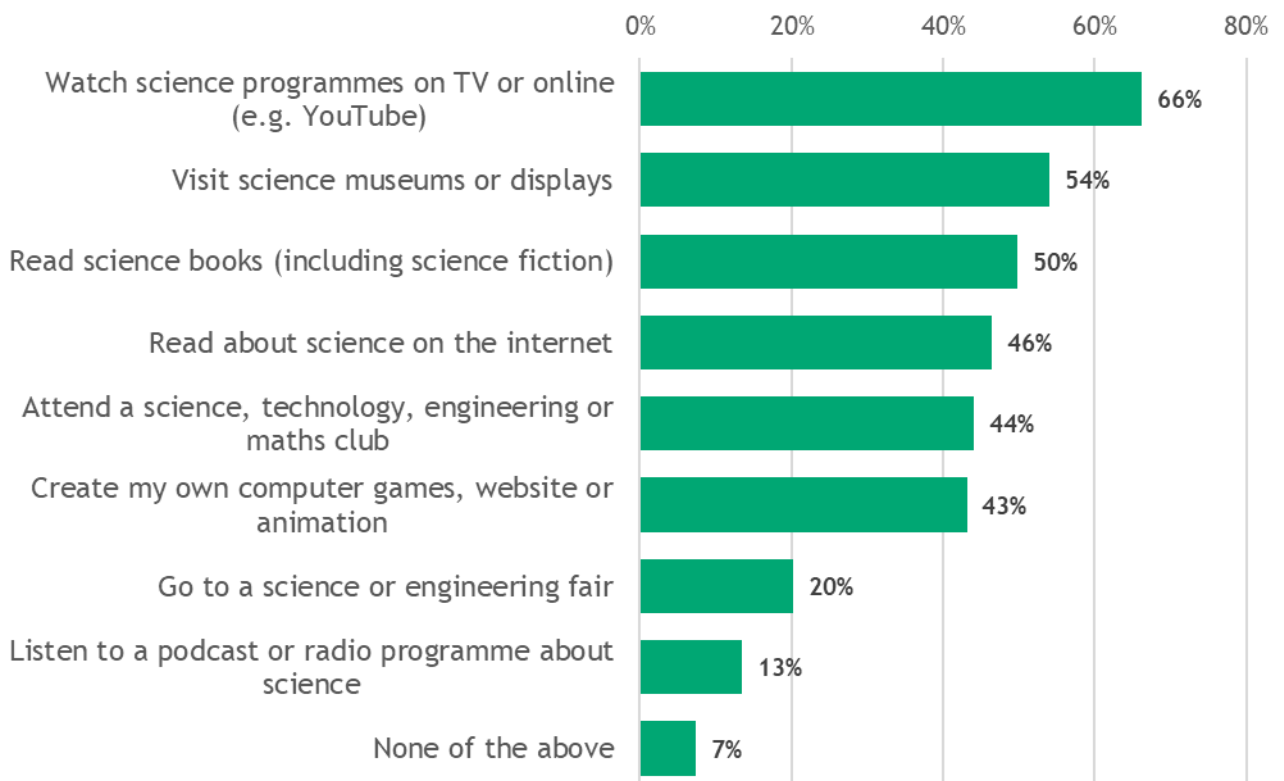
How do respondents engage with STEM?

We asked students a series of questions to explore their pre-existing engagement in STEM. Nearly all students responding said they participate in science related activities outside school, with over two-thirds (67%) reporting high STEM engagement.[2]

A majority of students said they watch science programmes on TV (66%), visit science museums or displays (54%) and read science books (50%). Interestingly, 43% reported they created their own computer games, website or animation. On average, students said they were already engaged in 3.4 of the 8 activities asked about.

While 29% of students reported not knowing anyone who works in a STEM related career, most of the respondents said they knew a parent or guardian (33%), another family member (29%), a family friend (23%) or someone else (23%).

Do you do any of the following science related activities outside of school? (n=424)

Activity	Percentage
Watch science programmes on TV or online (e.g. YouTube)	66%
Visit science museums or displays	54%
Read science books (including science fiction)	50%
Read about science on the internet	46%
Attend a science, technology, engineering or maths club	44%
Create my own computer games, website or animation	43%
Go to a science or engineering fair	20%
Listen to a podcast or radio programme about science	13%
None of the above	7%

Note: percentages do not add to 100% as respondents had the ability to select more than one response option.

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2. For the purpose of this report, student STEM engagement is categorised as high (for students taking part in 3 or more of the STEM activities listed in the chart), medium (for students taking part in 1 or 2 of the activities) and low (students not taking part in any of the activities listed).

Who responded to the teacher surveys?

Teachers were invited to take part in our feedback survey both through delivery partners sending out online links and by using QR codes at in person data collection during the Robotics Challenge heats.

We received 83 responses from teachers at 68 different schools. This represents 21% of all schools who engaged in the programme and 44% of schools who competed in the Robotics heats.

The schools responding to the teacher survey broadly reflect the characteristics of all the participating schools in terms of UK region though no responses were received from Northern Ireland. We had a slightly higher proportion of EDI criteria schools in the survey sample compared with those participating overall. The table below is based on the schools that participated overall, and those of the teachers responding to our survey.
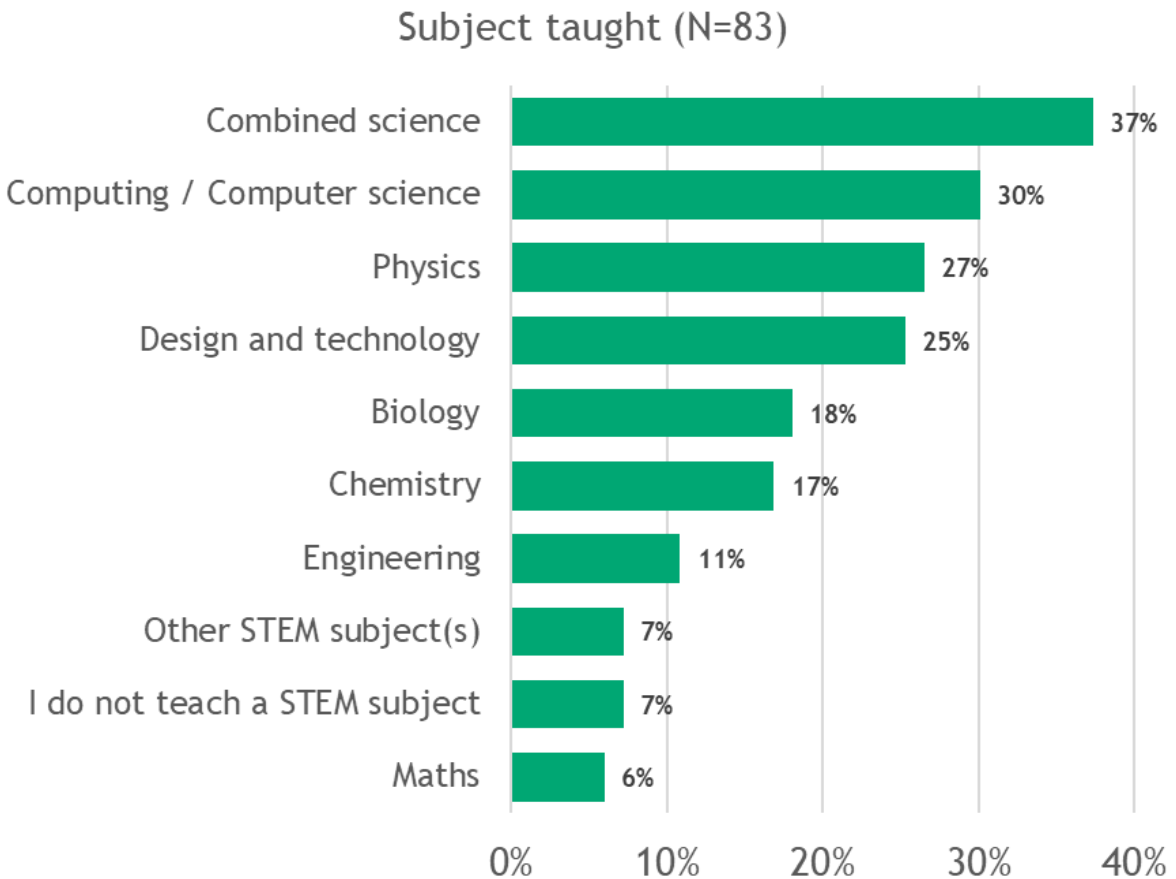
	All schools who reported engaging with Robotics Challenge N (%)	Schools responding to the survey N (%)
Total	321	68
UK nation		
England	269 (84%)	61 (90%)
Scotland	33 (10%)	5 (7%)
Wales	12 (4%)	2 (3%)
Northern Ireland	7 (2%)	0
Meets EDI criteria?		
Yes	147 (46%)	36 (53%)
No	174 (54%)	32 (47%)
Type of secondary school		
Single sex: Girls	31 (10%)	11 (16%)
Single sex: Boys	5 (2%)	1 (1%)
Mixed	232 (72%)	49 (72%)
No available data	53 (17%)	7 (10%)

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4. Data related to gender is not publicly available for all schools in Wales, Scotland and Northern Ireland.

What subjects do respondents teach?

Most of the teachers responding were science, computing or computer science teachers, with half indicating they teach more than one STEM subject.

One quarter (25%) of respondents said they teach design and technology. Very few teachers reported not teaching a STEM subject and even fewer reported teaching maths.

Nearly one-third (30%) of teachers who responded said they had some responsibility for careers advice in their school.

Subject taught (N=83)

Subject	Percentage
Combined science	37%
Computing / Computer science	30%
Physics	27%
Design and technology	25%
Biology	18%
Chemistry	17%
Engineering	11%
Other STEM subject(s)	7%
I do not teach a STEM subject	7%
Maths	6%

Note: percentages do not add to 100% as respondents had the ability to select more than one response option.

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Who participated in Robotics Challenge?

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Who participated in the programme?

Teachers deliver Robotics Challenge programme activities in their schools in a variety of ways: some facilitate sessions as part of their STEM club, others enable students who have been involved before to mentor new participants, and in some cases schools run internal competitions to determine those students who progress to the Robotics Challenge heats.

75% of teachers said students were able to decide for themselves if they wanted to take part

Among those who did not allow students to 'self-select' into the programme, some said their whole school took part (3%) or they selected a whole class (6%) or year group (1%) to participate. In a few cases, teachers specifically selected students from under-represented groups (3%). Others indicated they only selected students who were already part of STEM or enrichment clubs (3%).

Despite signing up to the programme, a few teachers reported that Covid disruption meant they were not actually able to participate, or only in part. This highlights the challenges that schools and students continued to face this year as a consequence of the pandemic.

"The kit and resources are very very good. We just struggled with running and maintaining clubs since Covid - this is not a fault of the Challenge itself."

Schools involve 10 students in Robotics Challenge activities, on average

Teachers who responded to the survey reported involving a number of students ranging from 1 to 30.

It is difficult to ascertain the number of students involved in the programme because not all students will necessarily have participated throughout all the activities. Some may have been involved for part of the challenge, and only some of those participating may have been able to attend the heats.

Given the variety of ways a school can participate, and that we only received information on the number of students from teachers at 58 schools, we cannot conclude that the findings presented here are representative of participation across all 321 schools engaged in the programme.

"I sent out an email to all of Year 8 ...Pretty much the only people that responded were people that I thought were gonna respond anyway. So it's, it's one of these sort of self-fulfilling prophecies"

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To understand the demographic characteristics of those participating in Robotics Challenge, teachers who responded to the survey were asked to share this information on the students involved in programme activities in 2021/22. Data collected is very limited and cannot be used to generalise the demographic characteristics of participants in Robotics Challenge.

Student gender

Through the teacher feedback survey, we have responses from 53 different schools (out of 321 schools engaged overall) who provided information on the gender of the students who participated in Robotics Challenge in 2021/22.

These teachers reported, **on average, 6 male students**[5] and **5 female students** [6] **taking part.**[7]

- 4 out of the 53 schools have reported 50% girls and 50% boys participating
- 31 out of 53 schools reported having more than 50% of boys participating (with 7 schools reporting 100% of their participants as boys, one of which is a single-sex boys school)
- 17 out of 53 schools reported having more than 50% of girls participating (with 10 schools reporting 100% of their participants as girls, 9 of which are single-sex girls schools)

Though these findings are not representative, they suggest that schools are rarely achieving the suggested 50/50 gender split, and that teams are mostly made up of mixed sex groups with a majority of male students.

When removing single sex schools, **the average gender split** reported is:
- **7 male students**
- **4 female students**

We recognise that gender is not binary and that there are ways young people identify that do not only fall in the categories of 'male' and 'female'. However, we have decided not to include averages given the low number who responded and the fact that this is based on teachers answering, possibly making assumptions about their students' gender identities. This data is only included in the report in instances where students shared this information directly.

For more information on the average number of students for other demographic information, Table 2 in the appendix provides this information by gender, ethnic group, year group, whether students receive free school meals and by disability.

5. Responses ranged from 0 to 23
6. Responses ranged from 0 to 30
7. Where teachers from the same school reported different numbers in terms of students who participated in Robotics Challenge, only the responses with the highest number of participants have been included in the calculation.

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Student and teacher experience of Robotics Challenge

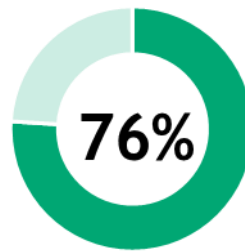# Student experience of Robotics Challenge

The programme's aim to inspire young people to consider further STEM study and careers is based on providing an experience that is enjoyable and engaging to young people. Students at Robotics Challenge heats overwhelmingly enjoyed taking part (86% enjoyed it a lot; 14% enjoyed it a bit), and they were inspired to do more, as a result of their participation.

88%

76%
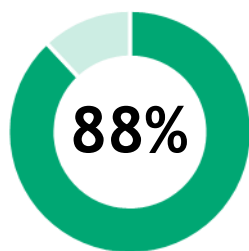
Students reported that Robotics Challenge has made them want to do more STEM activities.

Three-quarters said it made them want to find out more about engineering as a career.

Students with high STEM engagement are more likely to agree that Robotics Challenge has made them want to do more STEM activities,[8] and that the programme has made them want to find out more about engineering as a career,[9] compared to those with low STEM engagement. There was no significant difference by gender, ethnicity, year group or whether students receive free school meals.

The majority of students said they had not been to a Robotics Challenge competition event before (88%). Considering schools engaged in the programme in 2021/22 had already participated in previous years, this could be due to the fact that last year the competition was held virtually rather than at in-person events. Alternatively, schools may be ensuring that different students take part in the challenge each year.

"I enjoyed working together with people to achieve a goal. I found it really pleasing to be a part of creating our robot for the competition. I feel that it has allowed me to work more collaboratively with my close friends and peers."

"I liked being able to work as a team to complete the challenge and having to work out different ways to complete the challenge."

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8. Motivation to do more STEM activities by STEM engagement - Pearson Chi-squared, p-value = 0.008
9. Motivation to find out more about engineering careers by STEM engagement – Pearson Chi-squared, p-value = 0.003

Student experience of Robotics Challenge

Students completed the surveys throughout the day of the heat, so many will not have completed all challenges at the heat at the point they responded. They may also not have had the chance to engage with a STEM professional by then. The figure below shows the activities that young people said they had taken part in.

Activities students had taken part in (n=431)
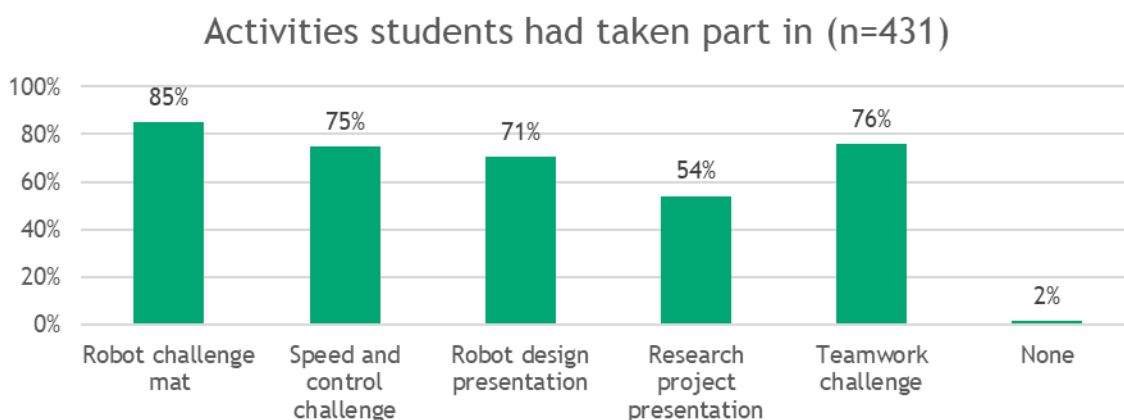
The Robotics Challenge heats observed by EngineeringUK staff collecting data in person consisted of a welcome and introduction session, the various challenge activities and concluded with an awards ceremony.

After initial information about the day shared by delivery partners, all teams competed for the first activity: speed and control challenge. Once completed, teams rotated throughout the other activity stations located across various areas in the venue. The surveys were administered to students only after teams had the chance to take part in at least two challenges.

Some activities, such as the speed challenge and challenge mats were required for all teams. Teams could choose to take part in just one of the Robotics design presentation or the Research project presentation, or to do both. Additionally, the teamwork challenge is the only activity for which students could not prepare, not knowing what the activity would consist of before taking part.

Considering the range of activities and teams of different sizes, not all students may have been involved in all activities, but could have distributed roles across the team. This could also explain why some students reported not taking part in the Speed and control challenge even though their team had.

The challenges were judged by various volunteers, who in most cases are STEM professionals. One third of students responding to the survey reported not having spoken to a STEM professional about their career in the sector during the heat.

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Student motivations for taking part

Overall, students chose to enter the competition to have fun (85%), to develop skills (71%) and because they want to study computer science in future (44%).[1]

There were some differences in the reasons to enter the competition for female and male students. The table to the right shows rankings by gender.

These findings suggest that girls are just as likely to choose to enter to have fun and to develop skills, but less likely because they want to pursue a career in computer science.

Male students may be more likely to link Robotics Challenge with their own future study and potentially career aspirations. This conclusion is further supported by a difference in male and female students' reported interest in a STEM career (see later in this report).

Female students (n=179)	Male students (n=211)
1. To have fun (84%)	1. To have fun (86%)
2. To develop skills (75%)	2. To develop skills (68%)
3. To meet other students who like STEM or Robotics (49%)	3. Because I want to study computer science in future (50%)
4. To present my ideas (44%)	4. To present my ideas (37%)
5. Because I want to study computer science in future (39%)	5. To have something to put on my CV or personal statement (37%)
6. Because my teacher / parent / guardian suggested I should (35%)	6. Because my friends were taking part (35%)
7. Because my friends were taking part (32%)	7. To meet other students who like STEM or Robotics (34%)
8. To have something to put on my CV or personal statement (27%)	8. Because my teacher / parent / guardian suggested I should (30%)
9. To get feedback on my work from scientists and engineers (26%)	9. To win prizes or awards (23%)
10. To win prizes or awards (22%)	10. To get feedback on my work from scientists and engineers (16%)
11. Another reason (4%)	11. Another reason (8%)

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Girls interviewed generally had a positive view of the UK finals and would want to take part again next year. Many were already interested in STEM, while a few mentioned they had not taken part in STEM activities before.

Interviews with female Robotics Challenge finalists were conducted with 6 teams at the Big Bang Fair in June 2022. Some were from all-female teams while others were mixed.

Team members typically had different roles; some focused on the design and build of the robots and others on project presentations. Interviewees told us roles were decided based on individual interests or strengths. Some students worked across all roles.

Aspects interviewees particularly liked about the finals include:

- Having fun
- Designing, coding and building their robot
- Adapting their robots based on trial and error during the competition
- Location of the finals (i.e. the venue itself/being an out-of-school event)
- Spending time with their team
- Seeing other competitors of a similar level

"I liked seeing other bright minds of our age"

"I chose Robotics because you can really change the world"

Interviewees said they found out about Robotics Challenge through their teachers, mostly during design and technology lessons or STEM clubs they are part of.

They mentioned a few reasons for taking part. Most were already interested in STEM, science or robotics:

- Wanted to join to have fun and to hang out with friends after school
- Most were already interested in STEM, science or robotics (some mentioning they saw STEM as fun already)
- Some mentioned that robotics was different to other 'classic' clubs (e.g. tennis or chess)
- Others had considered taking part before, but didn't have time last year
- Few mentioned not having done other STEM activities before

"I learned a lot from it [Robotics Challenge]. Before Robotics I didn't know how to code"

"I like science and robotics – it's just fun. So why not go into a competition that is fun?"

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Teacher experience of Robotics Challenge

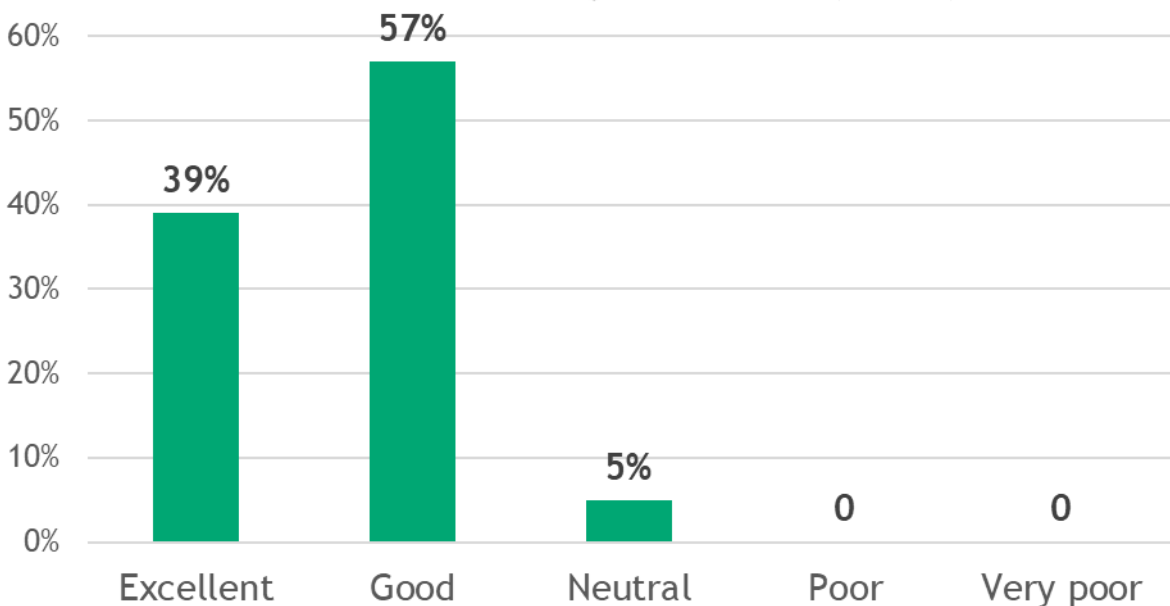**Teachers who responded were extremely positive about their experience of Robotics Challenge.**

95% of responding teachers rated Robotics Challenge as 'good' or 'excellent'.

Our analysis showed that the overall rating of Robotics Challenge did not differ between teachers at EDI and non-EDI schools.[10]

"It is an amazing hands-on activity for KS3 students that gives them opportunity to engage in physical computing. Students love it."

This positive finding is encouraging, but it may also be a result of receiving feedback from teachers who are most engaged in the programme, considering it is based on teachers from 68 out of 321 schools who reported participating in the programme (i.e. 21%).

How would you rate your experience of Robotics Challenge overall? (n=83)

Rating	Percentage
Excellent	39%
Good	57%
Neutral	5%
Poor	0
Very poor	0

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10. Pearson Chi-squared p-value = 0.264

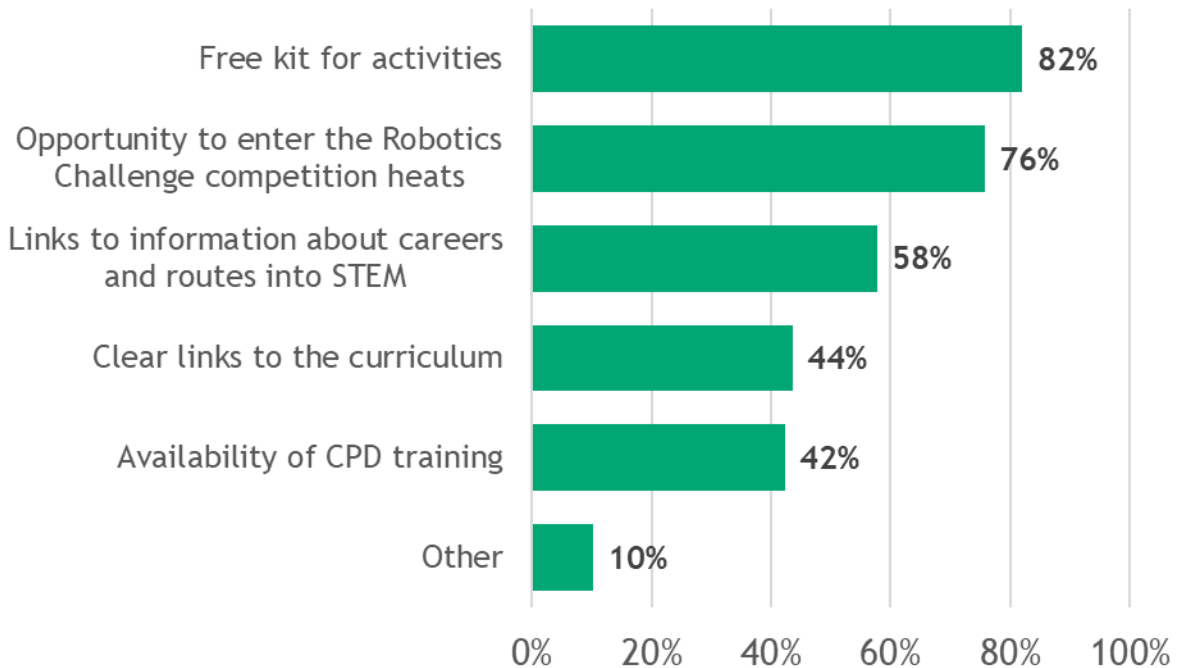# Teacher motivations for taking part

Robotics Challenge kit is regarded as an important element of the programme and is also used with other students beyond those directly involved in the challenge activities.

Just over **6 in 10 teachers** use kits with other students beyond those who participate in the programme.

The top three elements teachers selected as important in deciding to take part in Robotics Challenge include: free kit for activities (78%); the opportunity to enter the Robotics Challenge competition heats (72%); and the links to information about careers and routes into STEM (55%).

There was no significant difference in factors considered important in deciding to participate in the programme by whether teachers were from schools meeting our EDI criteria or not.

Which of the following are important to you in deciding to take part in Robotics Challenge? (n=78)

Category	Percentage
Free kit for activities	82%
Opportunity to enter the Robotics Challenge competition heats	76%
Links to information about careers and routes into STEM	58%
Clear links to the curriculum	44%
Availability of CPD training	42%
Other	10%

Note: percentages do not add to 100% as respondents had the ability to select more than one response option.

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Teacher experience of Robotics Challenge

Reflecting on their overall positive experience, three key aspects of Robotics Challenge were highlighted by teachers who responded: resources and support material, overall organisation and communication, and engaging challenges for students.

Resources and support material

Eighteen teachers referred to the programme resources and additional support when giving a positive rating of Robotics Challenge. A further 6 teachers specifically appreciated the introduction to the programme and teacher training.

Organisation and communication

Fifteen teachers mentioned the programme is well organised and 12 teachers highlighted clear communication as a reason for their positive rating. Some teachers reported liking the location and venues of the heats. Others specifically mentioned how helpful staff have been as well.

Engaging activities

Eleven teachers said the challenges were engaging for their students. A further 7 specified the skills that students gain from taking part. Some teachers commented that the activities are pitched at the right level, others mentioned the range of activities and the opportunity for students to get experiences outside the classroom.

It's also worth noting that while teachers overwhelmingly rated the programme positively, some also highlighted in their responses the challenges they faced over the past year:
- Limited teacher time
- Planning school-based robotics activities
- Old or limited amount of kit

Covid-19 also continues to be a challenge for some. One teacher told us that maintaining STEM clubs continues to be hard. Another teacher had noticed that students are less confident than in previous years, affecting their participation.

"The challenge is well organised and the provision of equipment is good with lots of communication and support available, as and when needed. The initial teacher/leader training session was very welcome and helpful. Our students find the challenge engaging and it particularly helps with their problem-solving skills and experience."

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To better understand experiences of Robotics Challenge and how schools participate in the programme, a total of 6 interviews were conducted with teachers. Some of the interview participants had been involved in Robotics Challenge for a number of years, whereas others were either just starting in 2021 or had begun the previous year during Covid-19.

Overall positive view

As with the teacher survey findings, interview participants had an overall positive view of Robotics Challenge. Five main themes emerged around aspects that interviewees valued about the programme:

- Provides 'stretch opportunities' for those already interested in STEM
- Offers activities that are not tied to school grades
- Recognises students' hard work
- Fosters opportunities for teamwork
- Pitched at the right level, with a focus on fun and learning more than competing

In addition, some teachers highlighted the training, resources and no cost to enter as main draws to get involved in the programme.

School participation

Teachers tend to find out about Robotics Challenge via 'word of mouth'. Understanding how teachers select students and how schools participate in the programme helps us contextualise the findings in this report and get a better sense of how participation varies.

Student recruitment
- Some teachers send invitation email to whole year groups, others mention the competition during their STEM lessons to recruit students to take part
- Some target students who have never experienced robotics before, or those who wouldn't have these kind of opportunities
- Participants tend to be students already interested/high attaining in STEM, unless a specific targeting approach is used

Kit and delivery
- Kit is used beyond only programme activities, e.g. in subject lessons to visually present topics like gears or pully systems
- Activities mostly delivered as part of afterschool clubs, or during lunchtime

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In depth: Teacher experience of Robotics Challenge

Beyond sharing their overall views of the programme and what teachers particularly enjoyed, some interviewees also highlighted challenges their schools faced in delivering Robotics Challenge over the past academic year.

Even though teachers who participated in the interviews had positive views of the programme, they also highlighted challenges their school faces in participating in Robotics Challenge. Five main themes emerged through the interviews, including:

- **Overall time and funding constraints**

- **Covid disruptions** – students in some schools still needed to work in bubbles over the past year, limiting interactions for activities; school closures and cleaning schedules limited the time available to run lunchtime robotics sessions or after school clubs.

- **Timing of activities –** some teachers highlighted that afterschool clubs are not accessible to all their students due to the timing. But lunchtime sessions are not long enough for students to take a break, eat and progress in the programme activities

- **Technical challenges** – some teachers faced challenges with software as well as limited kit.

- **Travel logistics** – travel requires permissions for students to be out of school, additional funding and staff as well as teacher cover.

"Previously we've run it as an after school club which has lasted for about an hour, an hour to two hours, but normally around the hour and half mark, which meant the students could really get into getting the kit out getting it built. Whereas we found this year, being limited to a lunchtime club, by the time you've got the kit out and started building something it was almost time to start packing it away and then checking that everything had been put back in the box. So that was the big challenge this year, and I've said next year it's going to be an after school activity."

"In September, personally, I've got other responsibilities that are going to get in my way. So I'm desperately trying to find someone who will be able to pick it up because it's such a valuable scheme."

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Teachers were asked how far they agreed that Robotics Challenge had met some of its key objectives:

- To be an engaging activity for students across levels of prior interest in STEM subjects
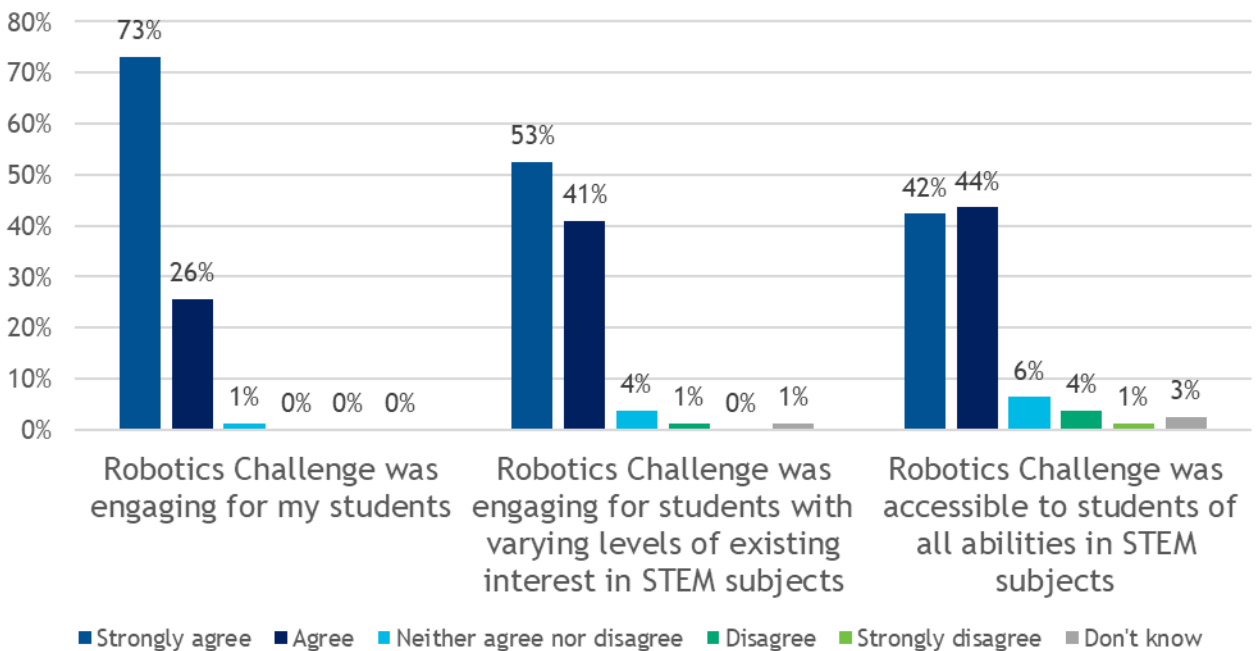- To be accessible to students across a range of abilities

Agreement was generally high across the board, with over 86% agreeing or strongly agreeing with the statements put to teachers.

There was lower agreement that Robotics Challenge was accessible to students of all abilities in STEM subjects.

We explore teachers' views about how engaging and accessible the programme is in the learning for improvement section of this report.

"It's a great motivator for the students. We can recruit a number of students who then commit to spending after-school time creating solutions to the challenges. The challenges require a wide range of different skills which fits with the school ethos of 'Achievement for all'"

Teacher views of Robotics Challenge (n=78)

	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree	Don't know
Robotics Challenge was engaging for my students	73%	26%	1%	0%	0%	0%
Robotics Challenge was engaging for students with varying levels of existing interest in STEM subjects	53%	41%	4%	1%	0%	1%
Robotics Challenge was accessible to students of all abilities in STEM subjects	42%	44%	6%	4%	1%	3%

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Teachers' experience: student engagement

Teachers were asked which activities were particularly engaging for their students. Free text responses were categorised to show which aspects of the programme were commonly mentioned:

Building the robot
Eleven teachers mentioned that building the robot was the most engaging activity for their students. Three teachers mentioned the hands-on aspects of the challenge as engaging in general.

Range of activities
Beyond the practical activities, 8 teachers shared that the range of activities is particularly effective in engaging their students. Seven teachers specified how the range is appealing to students of different skills, interests or comfort levels in taking part.

Challenge activities
Linked to the range of activities, similar number of mentions were given for specific robotics challenge activities:
 - Challenge mat (10 mentions)
 - Speed challenge (9 mentions)
 - Presentation (8 mentions)
 - Robot design (7 mentions)

Five teachers said they felt that all the challenges were engaging.

"Completing the challenges and building the robots - all students could get involved."

"Having a range of challenges has really helped. Some have felt more comfortable with the building, some the programming, others with creating presentations and doing the research. Lots of interesting discussions and building an effective team."

"The overall variety of aspects of the challenge is really useful as it gives all pupils a chance to excel at a different area - some pupils loved the speed/control challenge, some love researching problems and trying to come up with solutions, most of the pupils enjoy building robots and some of them are really keen to learn more about coding to be able to better control their robots."

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Teachers' experience: student engagement

Robotics Challenge aims to support students from groups under-represented in engineering careers to consider and eventually pursue a career in the sector. Teachers were asked about the extent to which they feel the programme was successful at engaging the following groups.

82% of responding teachers felt that Robotics Challenge was quite effective (43%) or very effective (38%) at engaging girls;

75% felt Robotics Challenge was quite effective (34%) or very effective (41%) at engaging students from low income households;

67% felt Robotics Challenge was quite effective (30%) or very effective (37%) at engaging students from minority ethnic groups;

75% felt Robotics Challenge was quite effective (34%) or very effective (41%) at engaging students with a disability.

The statement related to engaging with students with a from minority ethnic groups had the lowest agreement compared to the others, but also the highest number of teachers responding 'not very effective' (12%) and 'not applicable' (13%).

Teachers were also asked about their suggestions for ways to engage with students from groups under-represented in engineering. Their ideas are included later in the report.

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Informing, inspiring and empowering students and those who support them

Skills students gain from Robotics Challenge

Robotics Challenge aims to support students to develop hard and soft skills that are important for careers in engineering. Students who responded to the survey reported learning or improving a range of different skills.

Which of the following skills do you think you have learned or improved by taking part in the Robotics Challenge competition event? (N=426)

Skill	Percentage
Working as part of a team	87%
Learning from mistakes or when things go wrong	77%
Problem-solving	76%
Working well under pressure	66%
Communicating ideas clearly	65%
Being a good team leader	34%
Other	3%
None of the above	1%

When exploring for differences by respondents' gender, ethnicity, year group and by whether they receive free school meals, the following significant difference was found:

Resilience

Compared to boys, girls were more likely to say that by taking part in the Robotics Challenge competition event they had improved their resilience skills (82% of girls selecting 'learning from mistakes or when things go wrong' cf. 73% boys; Pearson Chi-squared p-value =0.035).

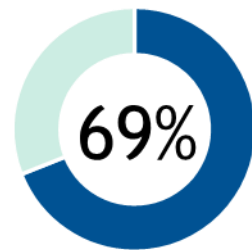**EngineeringUK**

Inspiring students

We asked students how interested they are in a career in science, engineering or technology related fields.

9 in 10 students said that they were interested in a career in at least one of science, technology and engineering.

The figures to the right show that between 69% and 81% of students attending Robotics Challenge heats were interested in the different fields of STEM-related careers. In contrast, the latest EBM shows that 55% of 11-14 year olds were interested in a career involving engineering, 55% were interested in a career in science, and 63% were interested in a career in technology.

Male students were more likely to be interested or very interested in a career in technology, compared to female students (84% and 78% respectively; Pearson Chi-squared p-value =0.016). There were no differences in interest in engineering or science by gender.
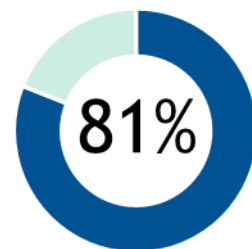
Students reporting they were interested or very interested in a career related to STEM

69%

**Engineering
(n=422)**

75%

**Science
(n=423)**

81%
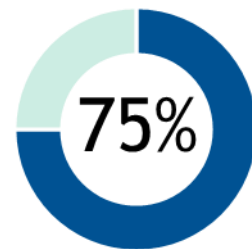
**Technology
(n=423)**

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Empowering students

For students to consider a career in engineering, they need to believe that they have the ability to succeed in their ambition, and that such a career is open to them. We asked students whether they thought they could become an engineer if they chose to.

77% of young people said they thought they could become an engineer if they wanted to.

Our analysis found that students with higher levels of STEM engagement are more likely to say they could become an engineer if they wanted to (92% students with high STEM engagement; 84% medium STEM engagement; 68% low STEM engagement).

There were no significant differences by gender, ethnicity, year group, whether students are from an EDI school or whether they receive free school meals.

If you wanted to, do you think you could become an engineer? (n=426)

- 1%
- 14%
- 20%
- 9%
- 56%
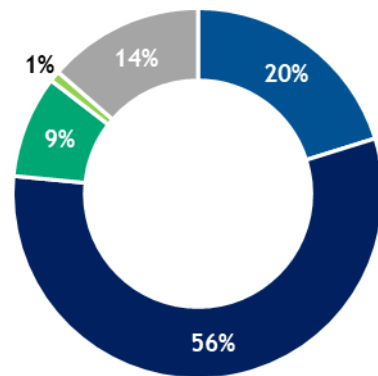
- Yes, definitely
- Yes, probably
- No, probably not
- No, definitely not
- Don't know

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As well as confidence in their abilities, students need to believe that an engineering career would suit them.

60% of young people agreed that engineering would be a suitable career for them

In line with higher interests in STEM careers, a higher proportion of Robotics Challenge competitors see engineering as a suitable career for them **than EBM participants** (54%).

Given the self-selecting nature of participants in the Robotics Challenge programme, we cannot say how far this reflects pre-existing interest and belief that STEM careers would be suitable for them before taking part in the programme.

Our analysis identified the following significant differences in students' agreement that engineering was a suitable career for them:

- Students not receiving free school meals are more likely to agree that engineering would be a suitable career for them (62%), compared to students receiving free school meals (38%); Pearson Chi-squared p-value=0.003)

- Students with high STEM engagement are more likely to agree that engineering would be a suitable career for them, compared to those with medium STEM engagement (67% and 49% respectively; Pearson Chi-squared p-value=0.002).

There were no significant differences by gender, ethnicity, whether students attend schools that meet our EDI criteria or by whether they engaged with a STEM professional at the Robotics Challenge heats.

I think that engineering would be a suitable career for me (n=434)
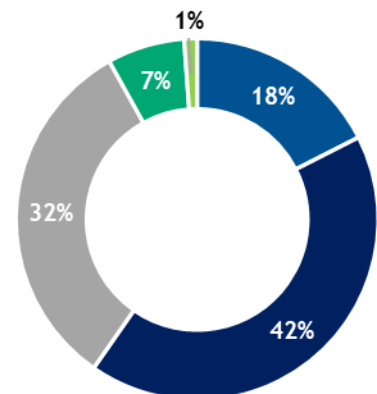
- Strongly agree
- Agree
- Neither agree nor disagree
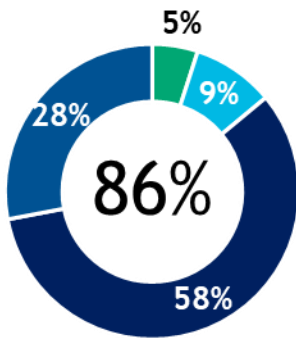- Disagree
- Strongly Disagree

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# Informing teachers about STEM careers

Robotics Challenge aims to support and inform teachers who provide careers advice to students. Teachers can be instrumental in encouraging students to follow STEM subjects and career paths but can also be a barrier if they do not know about the range of opportunities available in STEM.
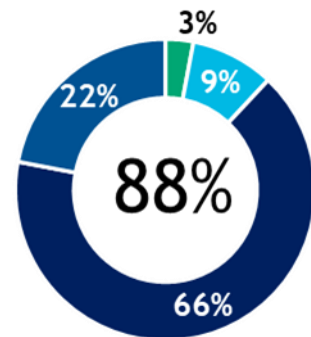
Knowledge about STEM careers

- Strongly disagree
- Disagree
- Neither agree nor disagree
- Agree
- Strongly agree

86%

5%
9%
28%
58%

Agree or strongly agree that they knew about the kind of things **engineers** can do in their jobs.

83%

3%
14%
22%
61%
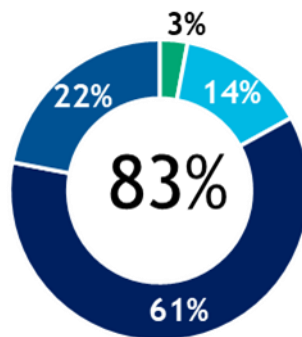
Agree or strongly agree that they knew about the kind of things **scientists** can do in their jobs.

88%

3%
9%
22%
66%

Agree or strongly agree that they knew about the kind of things **people working in technology** can do in their jobs.

Most teachers said they knew about what is involved in engineering, science and technology careers. Over 9 in 10 teachers also agree they are knowledgeable in the next steps that students would need to take to become an engineer.

This finding is interesting as it differs from some of our other programmes which instead suggest that teachers are more knowledgeable about careers and next steps involved in pursuing science rather than engineering or technology careers. It may be that this is a direct effect of participation in the programme and the information shared through Robotics Challenge.

However, it may also reflect prior knowledge in these areas, and the higher proportion of computer science and design and technology teachers in this sample.

91% agreed that they knew what subjects or qualifications their students would need to take next to become an *engineer*.

82% agreed that they knew what subjects or qualifications their students would need to take next to become a *scientist*.

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Beyond teachers' knowledge of STEM careers and next steps to pursue those pathways, it is important that they feel confident in providing advice to students.

55% of teachers said they were more confident giving engineering careers advice after taking part in Robotics Challenge

In general, responding teachers felt confident advising students around STEM careers, though confidence was slightly lower around science than engineering or technology.

77% of teachers felt fairly (52%) or very (25%) confident giving advice about science careers; 85% felt fairly (51%) or very (34%) confident giving advice about engineering careers; 82% felt fairly (51%) or very (32%) confident giving advice about technology careers.

Over 89% of respondents said they had recommended that a student consider a career in engineering in the last 2-3 years.

Over three quarters of respondents (76%) said they were more likely to recommend engineering as a career after taking part in Robotics Challenge.

A large majority of respondents agreed that their school supported pupils to develop the skills needed to pursue engineering: 32% strongly agreed, 45% agreed, 20% neutral and 3% disagreed; no respondent strongly disagreed.

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Exploring opportunities to engage younger students

In 2021/22, primary schools in the North East were invited and supported to enter the FIRST LEGO® League Explore (FLLE). Due to the timing of activities, some schools were not able to take part last year and are looking to engage in 2022/23. Below an overview of the process is presented as well as feedback from two primary school teachers who took part in our interviews.

A total of 13 primary schools were recruited in the spring and summer terms of the 2021/22 academic year. EngineeringUK supported these schools to enter the Institution of Engineering and Technology's (IET) FIRST LEGO® League Explore, a programme for students aged 6 to 9.

EngineeringUK worked with secondary schools currently involved in Robotics Challenge to recruit feeder primary schools to take part. In partnership with the IET, EngineeringUK sent robotics kit and FLLE class packs to the 13 primary schools involved.

All 13 teachers were invited to take part in our interviews. Four teachers expressed interest, but reported they had not yet delivered the programme activities by the time they were contacted due to various challenges:

- Staffing issues
- Curriculum-related tasks prioritised
- Timing of training and kit availability

All four teachers mentioned they would be interested in running the activities in the Autumn term of the 2022/23 academic year.

The feedback presented in this report is based on two interviews conducted. Both teachers were new to the programme. One teacher mentioned their school had not taken part in STEM outreach before, but had recently invested in a LEGO® innovation centre and were looking to do more in the future. The other teacher mentioned their school employs a computer specialist from their linked secondary school to teach their primary students one morning per week throughout the year. This school is involved in other STEM activities through the secondary school.

General feedback

- Process of receiving resources was easy
- Training was brilliant and resource pack really useful
- Programme is really engaging
- Reasons for joining included kit and improving computer literacy

Activity delivery

- Used between 4 to 5 kits per class
- Teams of 6 per kit
- Different roles allowed for discussions about future job roles
- One teacher made students rotate roles, allowing participants to have time before the activities to agree on roles and responsibilities

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Exploring opportunities to engage younger students

Beyond exploring teachers' overall experiences, the aim of the interviews was also to understand the impact teachers feel FLLE has had as well as any challenges faced and recommendations for improvements. While teachers provided feedback specifically on IET's programme, the insights below could also be useful considerations for other robotics programmes aiming to engage younger students.

Reflections on impact and challenges

- The overall message of teamwork and different team roles is valued
- Students liked having their own workbook to go through as they progress in the sessions
- Beyond FLLE delivery, other teachers were keen on using the kit in lessons next year

Overall, teachers were positive about the programme. The only challenge mentioned by both was related to not having storage solutions for the kit, which becomes also a challenge when wanting to use the kit beyond programme activities.

"We work in quite a bit of a difficult area. Children don't have a lot of aspirations. They come from broken homes, they come from homes where parents have never really worked or very little work. And certainly we don't have any professionals within our parents and so raising aspirations is a big thing for us. And therefore making sure that they are computer literate and that they can be shown a few avenues into the job world, I guess you'd say it's really, really important to us."

Delivery of FLLE sessions

During the interviews, teachers also reflected on what the best approach would be to deliver the programme; whether it should be in classrooms or during afterschool sessions:

- One interviewee said that running it in classrooms gave the chance to students who wouldn't have applied for an after school club to get involved; and they loved taking part
- The other interviewee found it challenging to run sessions as a whole Year 3 class and is looking to work with either Year 5 or with a STEM club

The latter teacher mentioned they had overestimated the ability of Year 3 students, who in some cases found it hard to follow the instructions. So the teacher selected fewer activities to run rather than the whole 12 sessions. This teacher also commented that it probably wouldn't have been an issue with Year 6 students.

"When they just did a bit of coding and then the motor started working, you could see their eyes light up, you know. It was like: "Wow! It's moving, it's moving!" "And the little light box, whoa!" Well, they could have played with that all day."

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Learning for improvement

Learning for improvement: teacher feedback

Teachers were asked for suggestions about how to improve engagement with students from groups under-represented in engineering. Three main themes emerged: providing accessible resources for beginner students; making challenges relevant to student experiences; using representative promotional material and resources for Robotics Challenge.

Accessible resources for beginners

This includes step by step guides, videos or visual cards for students on how to get started with building robots and having them follow simple instructions, before going on to learn about how to modify robots as they want or need them for the challenges.

"I feel like the girls in my group don't feel as confident getting started - maybe one easy to find video explaining how to make a very basic robot, make it move, make it follow a line would have helped with their confidence."

Challenges that are relevant to student experiences

This includes asking students to design robots to tackle contemporary issues around race, disabilities or injustices. Other suggestions included using themes that are more relatable to a wider audience, linking, for example, disability with the environmental challenges, using scenarios that will have more meaning for students.

"There could be a list of humanitarian / environmental issues with a video which highlights some problems to inspire the project presentation."

Representative promotional materials and resources

This includes having Robotics Challenge promotional material as well as supporting resources that are inclusive and visually represent students from under-represented groups in STEM. Some also specified the need for role models from these groups.

"We do not have any female or minority ethnic staff involved in robotics within our school, so having a video containing a broader range of people promoting the challenge and its merits would be really helpful."

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In depth: Ways to improve participation

Through the interviews, teachers shared their suggestions on ways to improve participation and engagement in schools. Themes emerged ranging from the use of kit, resources available and new challenges or point scoring

General suggestions

- Providing additional kit or flexible kit (i.e. not only using LEGO®)
- Supporting new teachers over the 'initial hurdle' of getting involved
- Raising awareness of the programme in schools
- Offering resources that are easy to use and student led
- Suggesting to schools different ways to participate (e.g. running school based finals & winners attend the Robotics heats)

Competition specific suggestions

- Providing clear information about the competition in advance
- Increasing the number of teams who can compete per school (e.g. max 2 or 3) or the number of students who can attend (e.g. bringing all students who participated even if only one team competes)
- Promoting 'authentic' role models
- Using Python for coding to link activities to classroom teaching
- Being more creative with challenges (e.g. giving schools the chance to suggest a new challenge for everyone to compete in)

"There's a lot of these things [robotics/computing programmes] out there, but it's gonna be just helping teachers get over that initial hurdle – 'this is doable'. Some teachers are just so scared about doing something new and having to go to speak to their tech department about installing something."

"I think maybe trying to have one girl that tries to encourage other ones so you've got these role models that already exist within the school. And then potentially taking them and making them more prominent in school. That's something that I haven't necessarily tried, 'cause it's all been external so far; playing videos to girls about role models externally, but I think that maybe more could be done to do it."

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In depth: Ways to improve participation

Female competitors interviewed during the UK finals were also asked their opinions on ways to improve the programme overall as well as ways to engage more girls.

Their reflections and suggestions include:

- Knowing others in the STEM club would encourage more students to take part
- Having a female teacher
- Making the competition accessible and increase visibility
- Sharing more information on what is needed to take part
- Talking more about uses of robotics and how it is applied everyday
- Including more experiences and case studies
- Adding another round of Robotics heats before the UK finals

Beyond the comments on ways to improve the programme above, some students said they didn't have any improvements to suggest, These participants mentioned that they liked the programme as it is already, especially the variety of challenges.

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Learning for improvement: teacher feedback

We asked teachers what additional support they would find helpful when speaking to students about engineering careers. Thirty-seven respondents gave suggestions about what would be useful for them.

Information about pathways and roles in engineering

Fifteen of the 37 teachers suggested that up to date information on different pathways into engineering and examples of a range of roles in those sectors would be helpful. Some specifically mentioned the usefulness of having example job summaries or profiles with roles and responsibilities outlined to share with students. Others mentioned it would be useful to have resources that clearly link Robotics Challenge activities to jobs or careers where such skills are used.

Meeting engineers

Nine of the 37 comments suggested that more interaction with engineers, particularly in-person, would be helpful, including with volunteers at Robotics Challenge heats. A further 5 teachers mentioned it would be helpful to have access to case studies from engineering professionals talking about their journeys into the sector.

Workplace engagement

Three teachers highlighted the value of work experience, workplace visits (either virtual or in person), and direct engagement with local employers. Though one teacher also highlighted their school continued to be limited in their engagement with local engineers over the past year due to Covid-19.

"Perhaps having knowledge about the area of specialism that staff at the events have e.g. if we knew one of the judges was from a Science background, then we could encourage our pupils to speak to them if they had an interest in a career in Science - this could probably be facilitated relatively easily by having colour coded badges with job titles that make it easier for pupils to understand what industry the judge is linked with"

"Engineering has changed in the 25 years since I was one! So more information about current Engineering 'hot' areas and future developments would be good. 'The jobs they'll do are the ones that don't exist yet'"

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In depth: Wider impact of Robotics Challenge

Another aim of the teacher interviews was to explore any wider impact that teachers feel Robotics Challenge has had in their school. The feedback below is presented based on the wider impact teachers commented on for students, teachers and schools.

Students
- Contributed to building their self-confidence
- Offered opportunities to interact with STEM professionals or other adults beyond teachers or parents
- Contributed to uptake in design and technology and computer science GCSEs

Teachers
- Offered opportunities for career development
- Contributed to considering a sequence of different external computing activities to engage students effectively from key stage 3 to 5

Schools
- The competitive element of the programme created a 'buzz' in the school community, getting students excited about tech
- Involvement in other STEM activities
- Culture shift in schools (linked to student excitement in STEM and sequencing of effective STEM activities)
- Use of kit in other subject lessons
- Interest in using robotics sessions in class (but limited by number of kits available and software).

One teacher highlighted it was hard to know the wider impact that can be attributed to Robotics Challenge specifically, considering they take part in a number of different STEM activities.

Beyond keeping in mind that some of the participating teachers may be involved already in multiple activities, it's also worth noting these reflections may be coming from teachers that are already highly engaged in Robotics Challenge or other robotics and computing programmes. However, these findings can highlight areas where the programme could decide to contribute further to support teachers and have a wider impact.

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In depth: Wider impact of Robotics Challenge

Female competitors interviewed during the UK finals were also asked about the impact they feel being a finalist has made to them.

Interviewees brought up the following themes related to the impact they feel being a Robotics Challenge finalist has:

- Opportunity to have fun
- Learn to code
- Improve confidence
- Opportunity to 'open up horizons'
- Help with computing at school (linked to coursework)
- Some already wanted to pursue STEM and the competition reinforced interest in robotics in future

Conclusions and recommendations
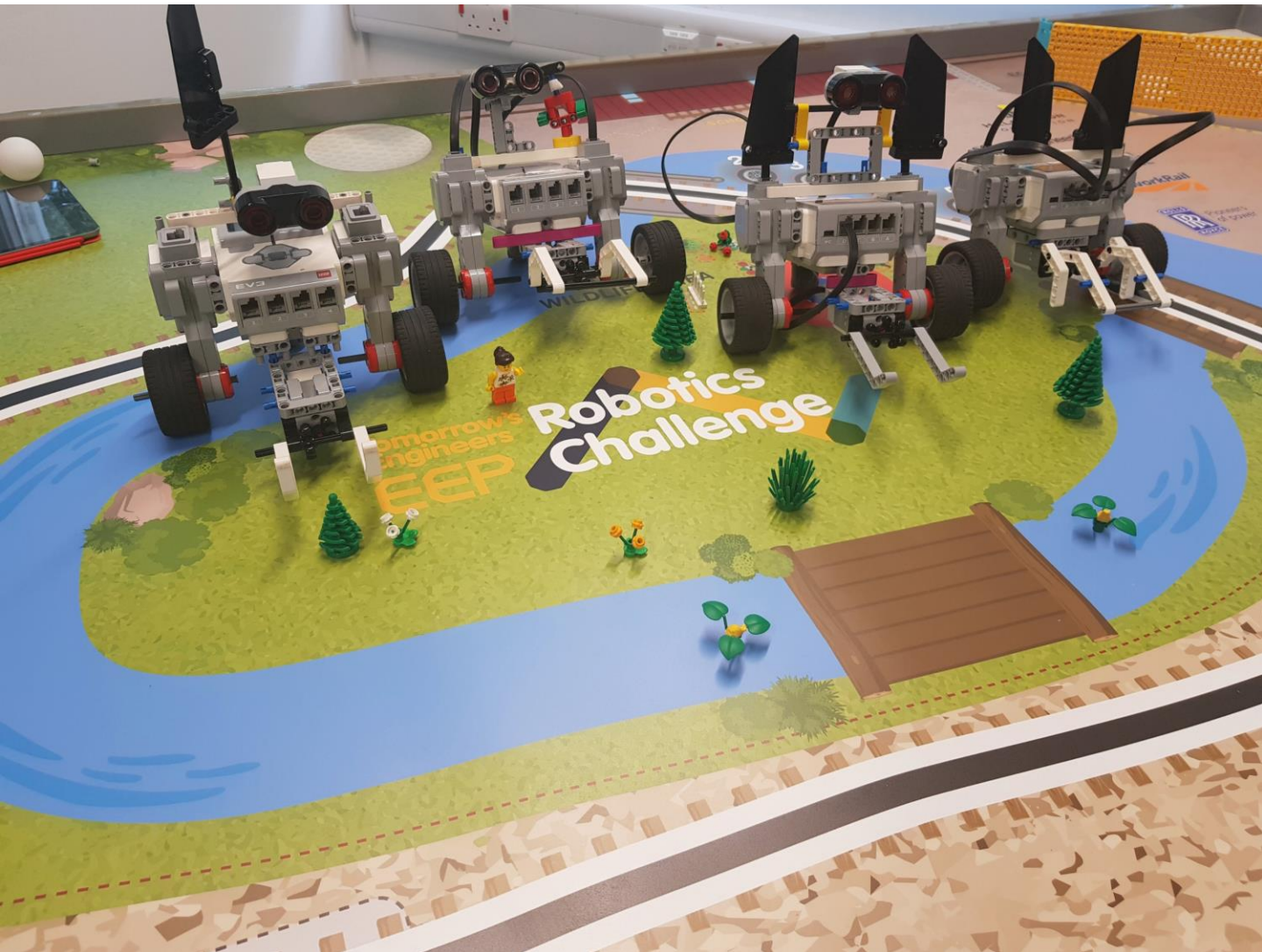
Conclusions

Robotics Challenge aims to deliver a fun, hands-on challenge that supports STEM teachers and inspires more young people (aged 10-14) from diverse backgrounds and under-represented groups in engineering to consider careers in the sector. Our evaluation findings suggest the most immediate outcomes of the programme were for the most part achieved. Both teachers and students shared their positive view of Robotics Challenge as activities that support students to develop skills and have fun. However, findings also suggest the that students involved in the competitions are for the most part already highly engaged in STEM.

Experiences of Robotics Challenge

Both students and teachers reported they enjoyed taking part in the programme and rated it highly. A positive finding is that there were no differences in the student enjoyment of the heats by gender. The wide range of activities, appears to be a reason why the heats are appealing for students of different interests and abilities.

The main motivation for students to enter the competition was to have fun and to develop skills. Interestingly, findings suggest that boys may be more likely to link taking part in the programme with their own future study and pursuit of a career in STEM.

Teacher support

The free kit for activities is regarded as an important element of Robotics Challenge. Teachers also highlighted as positive aspects the resources and support material available, the organisation and communication as well as the range of challenges (engaging for students and encouraging their skill development)

Inspiring students to consider a career in engineering

A majority of students felt that the programme made them want to do more STEM activities and find out more about engineering careers. This was particularly true for students who are already highly engaged in STEM activities. Students also reported learning a range of different skills.

Engaging students from under-represented groups in engineering

Overall, teachers reported that the hands-on elements of the activities, such as building robots, were particularly engaging for their students. Teachers tended to agree that Robotics Challenge was engaging to students with different levels of existing interest in STEM subjects and across a range of abilities. However, considering their feedback, the programme may not be as successful at engaging all students, in particular students from minority ethnic groups.

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Programme reach and participation

Robotics Challenge is delivered in different ways across schools. Our findings suggest that students mostly decide for themselves to get involved. Thus, we may be predominantly reaching students who are already interested in STEM. However, this may be the case only for the schools pursuing the competitive element of Robotics Challenge. We haven't been able to get such complete data about students and schools who sign up for the programme but don't enter the heats.

Teachers reported that, on average, 10 students per school participated in the programme. For the most part, students were invited to take part and could choose to join, though some interviewees highlighted the challenges they face with students dropping in and out of the sessions, meaning not all students who start the activities necessarily take part throughout.

Disruptions related to Covid-19 remained a challenge for some participating schools again this year, affecting their ability to run extra-curricular activities.

Wider impact

Teachers mentioned various ways in which the programme has impacted in their schools beyond among those participating directly in activities. There is also some evidence that teachers are using their kits with other students, beyond programme activities.

Limitations

As shown in this report, the students who attend the Robotics heats are, in large part, skewed towards having prior high STEM engagement and more likely to be interested in STEM. The data does not allow us to compare student views before and after taking part in the competitions, so we cannot conclude that the findings are the result of their experience at the heats.

Similarly, we see that teachers are more knowledgeable about engineering careers and confident in advising about them compared to science ones. This could be due to participation in the programme, but also due to the subjects they teach.

Recommendations

Based on the evaluation findings and feedback from teachers and students, the following are proposed recommendations for improvements.

Emphasise the teamwork element
While the competitive element was a motivation for teachers to take part, the focus on teamwork and development of soft skills is valued and 'working as part of a team' was a key skill students felt they developed via the programme.

Include challenges that are relevant to student experiences
Both teachers and students highlighted this as a way to improve engagement with students from groups under-represented in engineering. Girls also suggested talking more about everyday uses of robotics.

Clarify the link between activities and skills used in STEM careers
This would particularly benefit students who don't already make a link between participating in the programme and future STEM career aspirations. It could also benefit teachers who feel less confident advising on STEM careers.

Include diverse images and representations of STEM professionals
This should be consistent throughout promotional materials, perhaps including a communications resource pack for teachers to use for recruiting students in their own school. It should include diverse representation of STEM professionals, via case studies or volunteers.

Clarify what participation in the programme means
Findings presented in this report are based on students competing in the Robotics Challenge heats, but only about half of the schools who engage in the programme pursue the competitive element. Schools may be participating in various ways and may not consider themselves to have fully taken park without having attended the heats.

Clearly communicate what the competition component involves
Even though teachers highlighted the overall organisation and communication as positive aspects of Robotics Challenge, some teachers mentioned additional information about the competition would be beneficial in advance of taking part.

Trial classroom based resources
Research from Everfi has already led to the development of an 'Introducing Robotics' workshop for teachers to facilitate for a whole class or year group. There is potential for this to be beneficial particularly for new teachers, as a way to get involved in an initial step before engaging in programme activities.

If moving towards engaging younger students, carefully consider whether activities are age appropriate
While feedback from teachers involved in the primary pilot is limited, initial findings suggest that careful consideration needs to be given to the abilities of younger students.

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Appendix

Table 1. Robotics Challenge 2021/22 school characteristics by those engaging overall, those competing in the Robotics heats and the UK finals

School characteristics		All schools who reported engaging with Robotics Challenge N (%)	Schools who competed in the heats N (%)	Schools who competed in the UK finals N (%)
	Total	**321**	**153**	**39**
UK country / region	England	269 (84%)	125 (82%)	31 (79%)
	North East	*10 (3%)*	*8 (5%)*	*2 (5%)*
	North West	*58 (18%)*	*24 (16%)*	*4 (10%)*
	Yorkshire and the Humber	*13 (4%)*	*8 (5%)*	*4 (10%)*
	East Midlands	*29 (9%)*	*10 (7%)*	*1 (3%)*
	West Midlands	*29 (9%)*	*12 (8%)*	*3 (8%)*
	East of England	*18 (6%)*	*10 (7%)*	*3 (8%)*
	London	*40 (12%)*	*22 (14%)*	*6 (15%)*
	South East	*36 (11%)*	*16 (10%)*	*7 (18%)*
	South West	*36 (11%)*	*15 (10%)*	*1 (3%)*
	Scotland	33 (10%)	17 (11%)	7 (18%)
	Northern Ireland	12 (4%)	10 (6%)	1 (3%)
	Wales	7 (2%)	1 (1%)	0
Meets EDI criteria?	Yes	147 (46%)	73 (48%)	16 (41%)
	No	174 (54%)	80 (52%)	23 (59%)
Type of secondary school	Single sex: Girls	31 (10%)	17 (11%)	5 (13%)
	Single sex: Boys	5 (2%)	3 (2%)	1 (3%)
	Mixed	232 (72%)	103 (67%)	25 (64%)
	No available data	53 (17%)	30 (20%)	8 (21%)

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Table 2. Demographic data of students participating in Robotics Challenge provided by teachers

Demographic categories		Average number of students reported by teachers	Range of responses
Gender	Male	6-7	0 to 23
(n=53 schools; 16% of all schools participating)	Female	5-4	0 to 30
	Non-binary or other self description	0	0 to 1
Ethnic group	Asian/Asian British	2	0 to 14
(n=51 schools; 16% of all schools participating)	Black/Black British	1	0 to 23
	Mixed or multiple ethnic groups	1	0 to 15
	White	7	0 to 22
	Other ethnic identity	0	0 to 1
	Teachers don't know	0	0 to 5
Year group	Year 7 / S1 / 8	4	0 to 18
(n=53 schools; 16% of all schools participating)	Year 8 / S2 / 9	4	0 to 18
	Year 9 / S3 / 10	3	0 to 20
Receive Free School Meals	Yes	3	0 to 25
(n=50 schools; 16% of all schools participating)	No	8	0 to 22
Disability	Disability/ impairment	3	0 to 20
(n=47 schools; 15% of all schools participating)	Statement of special educational needs	2	0 to 20

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